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Bioventing and Natural Attenuation Technology Demonstration at Rhein-Main Air Base, Frankfurt, Germany

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This project involved the installation and operation of a bioventing system and the evaluation of natural attenuation of a mixed fuels spill at the Petroleum, Oils, and Lubricants (POL) Yard at Rhein-Main Air Base, Germany. Initially air was injected into the vent wells at a rate of 350 L/min (12.5 cfm) using a regenerative air blower. The blower was subsequently replaced with an oil-less air compressor delivering an equilibrium flow of 196 L/min (7 cfm) at a pressure of 24 psi (165 kP). Data gathered indicated that bioventing was stimulating biodegradation of the hydrocarbon contaminants at the site. It is calculated that 2,800 kg total hydrocarbon was removed during the project. Surface emissions at the site appeared to be minimal.

Data was collected on the hydrocarbon plume associated with the site of the biodegradation. A reduction in plume concentration is generally considered evidence of natural attenuation, provided that it is known that the plume source is being removed and that the plume is not increasing in size. The conclusion that natural attenuation is occuring at this site was most strongly supported by the distribution and spatial trend of contaminant constituents, electron acceptors, and degradation products upgradient and immediately downgradient of the source. Dissolved oxygen data showed that aerobic conditions were clearly present upgradient from the source, and that the aquifer became far less rich in oxygen under the POL Yard. There was clearly a reduction of electron acceptors under the POL Yard and at the first downgradient location. Metabolic byproducts were increasing from the upgradient location to the downgradient location, all indicating natural attenuation.

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
D/NETDP	Department of Defense/National Environmental Technology Demonstration Program
DO	dissolved oxygen
Eh	oxidation/reduction potential
GC	gas chromatography
GP	Gasmeßstelle (soil-gas monitoring point)
GP	GeoProbe®
GWM	Grundwassermeßstelle (monitoring well)
I.D.	inside diameter
LNAPL	light, nonaqueous-phase liquid
ND	not detected
NS	not sampled
MP	monitoring point
msl	mean sea level
MW	monitoring well
NM	not measured
O.D.	outside diameter
POL	petroleum, oils, and lubricants
ppmv	part per million by volume
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RM	Rhein-Main
SERDP	Strategic Environmental Research Development Program
SGS	soil-gas survey
TKN	total Kjeldahl nitrogen
TP	total phosphorous
TPH	total petroleum hydrocarbons

U.S. EPA	U.S. Environmental Protection Agency
UST	underground storage tank
UXO	unexploded ordnance
VOA	volatile organic analysis
VOC	volatile organic compound
VW	vent well
YSI	Yellow Springs International

EXECUTIVE SUMMARY

This report describes activities conducted at Rhein-Main Air Base, Germany. This project was conducted by Battelle Memorial Institute for the Air Force Research Laboratory, Tyndall Air Force Base (AFB), Florida, and was funded by the Strategic Environmental Research Development Program (SERDP). This project involved the installation and operation of a bioventing system and the evaluation of natural attenuation of a mixed fuels spill at the Petroleum, Oils, and Lubricants (POL) Yard at Rhein-Main Air Base, Germany.

In 1997 it was learned that the scope of this project was to be reduced. Therefore, field activities were minimized until a new scope was defined. The bioventing system operations were continued; however, no field monitoring was conducted. In October 1997, the revised scope was received. A field maintenance trip was conducted in early December 1997 to ensure that the system was functioning properly. Minimal monitoring activities were conducted throughout 1998, and final soil and groundwater sampling activites took place in September and October 1998. This annual report provides a summary of all activities conducted from project initiation to the present time.

Bioventing Testing

The bioventing test site is located at the POL Yard at Rhein-Main Air Base. Rhein-Main Air Base is an active air base located just outside Frankfurt, Germany. The 469th Air Base Squadron is Rhein-Main's host unit. The mission of the Base is to maintain an infrastructure ready for major airlift contingencies and to provide Base operating support.

The test site is in the POL Yard and is located near an underground pipeline that formerly was used to transfer fuel from underground storage tanks (USTs) to vehicles. The tanks contained primarily diesel fuel, although it is believed that they also periodically stored jet fuel. The pipeline and USTs have since been removed.

Site characterization activities included an initial soil-gas survey, an in situ respiration test, and initial soil and soil-gas analyses. Results from the soil-gas surveys indicated that both of the investigated areas were contaminated and contained high microbial activity. These results suggested that bioventing was likely to be a feasible remedial technology for this site.

Installations in the bioventing test plot included the following: four vent wells (VWs), four eight-level soil-gas monitoring points (MPs), and three 2-inch-diameter polyvinyl chloride (PVC) groundwater monitoring wells (MWs). The bioventing system consisted of a regenerative air blower plumbed to the air injection (vent) wells in the test plot. Operation of the bioventing system involved introducing oxygen into the vadose zone by injecting atmospheric air into the contaminated subsurface with the blower. Beginning in June 1996, air was injected at a rate of 350 L/min (12.5 cfm) into each vent well.

In December 1997, the regenerative air blower was replaced with an oil-less air compressor. A ¼-inch (0.64 cm) tube was placed in monitoring well MW1 at a depth of 8.8 m (29 ft) bgs and connected to the oil-less air compressor. The compressor was started and run until it reached equilibrium. The flowrate reached 196 L/min (7.0 cfm) at a pressure of 24 psi (165 kP). The pressure at the monitoring well was 0.35 bar.

The field tests conducted to date for this project consisted of (1) surface emissions testing; and (2) soil-gas permeability testing. System monitoring included regular field soil-gas sampling, soil temperature analysis, and in situ respiration tests. Based on the results from the study period, the following can be concluded:

1. The bioventing process is stimulating biodegradation. The average in situ respiration rate at a depth of 0 to 3 m was initially 1.8 mg/kg-day during the warm months and 0.42 mg/kg-day during colder months. At a depth of 3 to 6 m, the average in situ respiration rate during the warm months was initially 0.36 mg/kg-day and 0.18 mg/kg-day during colder months. During the final respiration test, conducted in a warm month, the average in situ respiration rate was 0.56 mg/kg-day at a depth of 0 to 3 m and 0.15 mg/kg-day at a depth of 3 to 6 m. Since the initiation of bioventing, these rates correspond to an estimated 2,800 kg total hydrocarbon removal.

2. Surface emissions at the site appear to be minimal. Surface emissions measured in October 1996 and again in August 1998 allowed for comparison of emissions with injection and without injection. Surface emissions measured in October 1996 were significantly lower than those measured during initial testing in April 1996. In most samples, no BTEX components could be detected. Very little difference could be detected between samples collected with injection and without injection. In the center of the test plot, no benzene, ethylbenzene, or xylenes were detected in any samples either with or without injection, and only trace amounts of toluene were detected during injection. In general, August 1998 surface emissions were significantly lower than those measured in April 1996, and were somewhat greater than those measured in October 1996. The average benzene concentrations in the center of the test plot both with and without injection were below the initial benzene concentrations in surface emissions prior to treatment. These data again show that operation of the blower does not seem to affect surface emission concentrations of benzene in the center of the test plot. Benzene concentrations in perimeter samples collected both with and without blower operation were less than benzene concentrations in initial surface emission samples at the site. These results indicate that, at the locations sampled, the bioventing system is not creating a pronounced level of increased emissions greater than natural surface emissions at the site.

3. Pressure changes were monitored at all depths during the soil-gas permeability tests. In general, the radius of influence was greater at the deeper depths, with values ranging from 4.6 m (15 ft) at a depth of 2 m (6.6 ft) up to 11 m (37 ft) at a depth of 4 m (13 ft). Based on the data for the POL Yard and assuming that most of the contamination generally is at deeper depths, a radius of influence of 9 m (30 ft) may be sufficient for site coverage. This radius would necessitate a well spacing of 18 m (60 ft). At the 18-m spacing, approximately 12 wells would be sufficient to treat more than 4,000 m^2 ($\sim$1 acre) of site surface area.

4. Results of soil-gas analyses generally agree with soil analyses, demonstrating that contaminant concentrations are heavier at distances closer to the old pipeline and at deeper depths. The exception is shown at monitoring point MPB, where significant contaminant concentrations are found at a shallower depth, and are believed to be the results of a surface spill.

distribution is known better. Additional vertical and lateral sampling should be performed at both existing and at new locations. It would also be helpful to learn more about the history of the spill.

- **Verification of the water quality parameter measurements.** To date, the results from the Hach® kits and GC have not been verified by independent laboratory analyses. Some of the data collected by the YSI instruments were verified by using another instrument that was available in the field, but that verification process was not rigorous. Verification of all instrument-derived data would increase confidence in the results and conclusions.

- **Collection of additional background data.** It would be very useful to collect background data at more than one location. These data would provide greater insight into ambient concentration for the various water quality parameters, and should be collected at locations that are upgradient and outside of the POL Yard.

- **Develop and implement a groundwater monitoring plan.** Once the plume has been fully delineated, a monitoring program should be planned and implemented to chart the progress of plume reduction and the trend of the relevant natural attenuation parameters. This plan should be presented to all stakeholders (local citizens, government regulators, and Base officials) to gain approval to implement a monitoring program that lasts at least two years, consisting of sample collection on a quarterly basis. A more extensive data set needs to present convincing and defensible evidence of natural attenuation.

- **Development of a numerical model.** This model would (1) represent all known site conditions, and (2) simulate and predict the rate of natural attenuation and its impact on the plume and overall groundwater quality with the progression of time.

FINAL REPORT

on

BIOVENTING TECHNOLOGY DEMONSTRATION AT RHEIN-MAIN AIR BASE, FRANKFURT, GERMANY

10 September 1999

This report describes activities conducted at Rhein-Main Air Base, Germany. This project was conducted by Battelle Memorial Institute for the Air Force Research Laboratory, Tyndall Air Force Base (AFB) Florida. The project was funded by the Strategic Environmental Research Development Program (SERDP). This project involved the installation and operation of a bioventing system, and evaluation of natural attenuation of a mixed fuels spill at the Petroleum, Oils, and Lubricants (POL) Yard at Rhein-Main Air Base, Germany.

During 1997, it was learned that the scope of this project was to be reduced. Therefore, the field activity was minimized until a new scope was defined. The bioventing system continued to be operated; however, no field monitoring was conducted. In October 1997, the revised scope was received. A field maintenance trip was conducted in early December 1997 to ensure the system was functioning properly. Minimal monitoring activities were conducted throughout 1998, and final soil and groundwater sampling occurred in September and October 1998. This annual report provides a summary of all activities conducted at the POL Yard from project initiation to the present time.

5. During August 1996, in situ respiration rates were greatest at depths of 3 m and less in the vicinity of monitoring points MPA and MPB. The lowest rates were found in the area of monitoring point MPD. These results correlate with soil and soil-gas analyses, which demonstrated that the highest levels of contaminants exist in the region of monitoring points MPA and MPB, with little contamination in the region of monitoring point MPD. Higher contaminant levels will result in higher in situ respiration rates. Soil sample results also demonstrated the presence of significant contaminant concentrations at a depth of 7 to 8 m bgs; however, these soils are saturated, preventing the use of in situ respiration testing. In situ respiration rates measured during November 1996 were significantly lower than August 1996 rates, most likely the result of significantly lower soil temperatures. In situ respiration rates measured in August 1998 also were lower than August 1996 rates even at similar soil temperatures, indicating a reduction in contaminant concentrations in soil.

6. In general, the highest initial soil contaminant levels were found at deeper depths, close to the location of the former pipeline. Total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX) also were high at shallower depths near the southeastern portion of the test plot. POL Yard personnel reported that there was a large surface spill in this area that probably resulted in the contamination in the test plot at these depths. TPH concentrations ranged from below detection limits to approximately 2,000 mg/kg, and BTEX concentrations ranged from below detection limits up to approximately 20 mg/kg. The total mass of TPH initially in soil is estimated to be 1,920 kg, a number based on average TPH concentrations in soil by depth prior to the initiation of bioventing. All values of the inorganic parameters fell within ranges observed at successful bioventing sites. Results of final soil sampling indicate a significant reduction in contaminant concentration in soil with the exception of several depths below the water table level. In general, the highest final TPH and benzene concentrations were found in vent wells VW-1 and VW-3 at deeper depths that are saturated during part or all of the year. TPH and BTEX also remained slightly elevated at several shallower depths, possibly associated with the surface spill mentioned above. However, concentrations at these locations were significantly lower in the final sampling event in comparison to concentrations measured in the initial sampling event.

Natural Attenuation Study

Site characterization activities conducted as part of the natural attenuation study were patterned on those recommended in the U.S. Air Force Protocol for natural attenuation studies (Wiedemeier et al., 1995). The site characterization was designed to evaluate the nature and extent of petroleum contamination in groundwater as well as to determine if evidence of natural attenuation, and specifically intrinsic biodegradation, is present. Intrinsic biodegradation is the most important of several natural processes at play within a plume that is undergoing natural attenuation. It is most important because it is the only one of several natural attenuation processes that transforms contaminants into innocuous byproducts and reduces the total mass of contaminants in the subsurface.

A reduction in plume concentration is generally considered evidence of natural attenuation, provided that it is known that the plume source is being removed and that the plume is not increasing in size. Evidence of intrinsic biodegradation is found by collecting groundwater quality data from

points scattered across the area of the plume, from points within the source area, and from nonimpacted upgradient locations.

Site characterization activities focused on collecting two temporal data sets to (1) determine the nature and extent of a plume caused by a release of petroleum-related contamination and (2) collect specific water quality parameters directly related to the intrinsic biodegradation of the plume. The second data set was collected two years after the first to determine if the levels of contamination were dropping over that two-year time period and if water quality parameters and concentrations of compounds related to intrinsic biodegradation concurrently were following anticipated trends.

The GeoProbe®-based groundwater sampling and analysis performed downgradient of the known fuel leak in the POL Yard indicated that a dissolved-phase plume had been created in the water table aquifer. This plume contains TPH and BTEX constituents that have moved in the direction of groundwater flow (northwest) toward the Base boundary. Sampling and analysis indicates that TPH is present at concentrations as high as 1 mg/L at least 220 m northwest of the POL Yard, and benzene is present at concentrations as high as 5 μg/L at least 330 m northwest of the POL Yard. The vertical extent of the plume has not been fully defined.

The limited amount of data collected during the two field surveys— spatial distributions of contamination, degradation byproducts, electron acceptors, and relevant field parameters— generally indicated that intrinsic biodegradation is taking place within the plume. The trends of key parameters, especially across the source area from the upgradient to the first of the downgradient sampling locations, reflected conditions that are present when a hydrocarbon plume is undergoing intrinsic biodegradation, (the most significant natural process).

There are erratic distributions of many of the key parameters. This can be attributed to aquifer heterogeneity (both laterally and vertically within the aquifer), the presence of other potential downgradient sources, and operator and instrument error during data collection and analysis.

The conclusion that natural attenuation is occuring was most strongly supported by the distribution and spatial trend of contaminant constituents, electron acceptors, and degradation products upgradient and immediately downgradient of the source. Dissolved oxygen data showed that aerobic conditions were clearly present upgradient from the source, and that the aquifer becomes far less rich in oxygen under the POL Yard. The aquifer remained relatively low in oxygen at most downgradient locations where measurements were collected. There was clearly a reduction of electron acceptors under the POL Yard and at location GP-2, the first downgradient location. Conversely, metabolic byproducts were increasing from the upgradient location, across the POL Yard, and downgradient to location GP-1. Together, these trends suggest that intrinsic biodegradation processes are acting on the hydrocarbon contaminants in the groundwater.

The collection of a more extensive data set is needed to determine which specific biodegradation processes are present at this site, and then to calculate the rate of degradation. This data set should include the following:

- **Better characterization of the hydrocarbon plume.** Specifically, greater knowledge of the distribution of TPH and BTEX is needed. More meaningful conclusions can be drawn from concentrations of electron acceptors and degradation products if the plume

SECTION I
INTRODUCTION AND BACKGROUND

This section introduces the bioventing technology demonstration conducted at Rhein-Main Air Base, Germany. The introduction includes a discussion of the general need for innovative technologies, a brief description of bioventing and natural attenuation, and a presentation of the scope of work for the technology demonstration.

A. TECHNOLOGY NEED

Historic handling practices and past spills and leaks have caused petroleum releases to the environment to occur at most industrial and government fuels-handling facilities. When a fuel release occurs, the contaminants may be present in any or all of three phases in the geologic media: adsorbed to the soils in the vadose zone, floating on the water table in free-phase form, and/or in solution phase dissolved in the groundwater. Of the three phases, dissolved petroleum contaminants in the groundwater are considered to be of greatest concern due to the risk of human exposure through drinking water. However, the liquid- and adsorbed-phase hydrocarbons act as feedstocks for groundwater contamination, so any remedial technology aimed at reducing groundwater contamination must address these contaminant sources.

Petroleum distillate fuel hydrocarbons such as diesel fuel are generally biodegradable if naturally occurring microorganisms are provided an adequate supply of oxygen and basic nutrients. Natural biodegradation does occur and, at many sites, eventually may mineralize most fuel contamination. However, due to heavy contamination in source zones, an acceleration or enhancement of the natural biodegradation process may prove the most effective remediation for these areas.

To date, bioventing and natural attenuation have been demonstrated as effective remedial technologies in the United States. However, they have yet to be widely demonstrated in Germany and must be proven effective remedial technologies to German environmental regulatory agencies in order for bioventing and natural attenuation to be applied at U.S. military installations in Germany. The present study is a demonstration of bioventing and natural attenuation conducted in a manner satisfying the mission and goals of the Department of Defense/National Environmental Technology Demonstration Program (D/NETDP).

B. TECHNOLOGY OVERVIEW

Bioventing and natural attenuation are being demonstrated in a combined process for remediation of source zone and groundwater contamination. Bioventing is being demonstrated as a source zone remediation technology, while natural attenuation is being demonstrated as a groundwater remediation alternative.

1. Bioventing

Bioventing is a process designed to deliver adequate supplies of oxygen to the subsurface environment to support aerobic biodegradation of target contaminants. Oxygen is delivered through induced air movement either by applying a vacuum and withdrawing soil gas or by air injection.

When air is the oxygen source, the minimum stoichiometric ratio of air to hydrocarbon on a mass basis is approximately 13 to 1. This ratio is in contrast to a water to hydrocarbon ratio of more than 10,000 to 1 for a conventional waterborne-enhanced bioreclamation process. An additional advantage of using an airborne process is that gases have greater diffusivity than liquids. At many sites, geologic heterogeneities present a problem for a waterborne oxygen source because fluid pumped through the formation is channeled into the more permeable pathways. For example, in an alluvial soil with interbedded sand and clay, initially all of the fluid flow will take place in the sand. As a result, oxygen must be delivered to the less-permeable clay lenses through diffusion. In a gaseous system (as is found in unsaturated soils), this diffusion can be expected to take place at a rate several orders of magnitude greater than in a liquid system (as is found in saturated soils). Although it is not realistic to expect diffusion to aid significantly in water-based bioreclamation, in an air-based application, diffusion may be a significant mechanism for oxygen delivery to less-permeable zones.

Bioventing has been demonstrated to be effective at any site that is contaminated with biodegradable compounds and at which the microbial populations are present that can degrade the target contaminants. This includes sites contaminated with diesel or JP-4 jet fuel and other jet fuels as well as fire protection training areas that are contaminated with a wide range of petroleum-based contaminants.

The use of an air-based oxygen supply to enhance biodegradation relies on air flow through hydrocarbon-contaminated soils at rates and configurations that will both ensure adequate oxygenation for aerobic biodegradation and minimize or eliminate the production of a hydrocarbon-contaminated off-gas. The addition of nutrients and moisture may be desirable to increase biodegradation rates; however, field research to date does not support this (Dupont et al., 1991; Miller et al., 1991). Dewatering may be necessary at times, depending on the distribution of contaminants relative to the water table. However, because dewatering is already required at many fuel hydrocarbon-contaminated sites, this is not likely to present a problem. A key feature of bioventing is the narrowly screened soil-gas monitoring points that sample only a short vertical section of the soil. These points are required to determine local oxygen concentrations, because the oxygen levels measured in the vent well are not representative of local conditions.

A bioventing system may be configured in one of two different ways to enhance biodegradation: air extraction or air injection. The optimal configuration for any given site will depend on site-specific conditions and remedial objectives.

Air injection is the configuration of choice for bioventing at the POL Yard. Air injection is the lowest cost configuration, but careful consideration must be given to the fate of injected air. The objective is to degrade hydrocarbons, resulting in carbon dioxide emissions at some distance from the injection point. If a building or subsurface structure exists within the radius of influence, hydrocarbon vapors may be forced into that structure. Therefore, protection of subsurface structures may be required.

Alternatively, a system may be constructed in which air is injected (the injection may be by passive wells) into the contaminated zone and withdrawn from clean soils. This configuration allows the more volatile hydrocarbons to degrade prior to being withdrawn, thereby eliminating contaminated off-gases.

A configuration that may alleviate the threat to subsurface structures while achieving the same effect as air injection alone would involve extracting soil gas near the structure of concern and reinjecting it at a safe distance. If necessary, make-up air can be added before injection.

The significant features of the bioventing technology include the following:

- Optimizing air flow to reduce volatilization while maintaining aerobic conditions for biodegradation.

- Monitoring local soil-gas conditions to ensure aerobic conditions, not just monitoring vent gas composition.

- Manipulating the water table as required for air/contaminant contact.

2. Natural Attenuation

Intrinsic biodegradation, also known as natural attenuation, is a passive remediation method that can effectively reduce petroleum contamination in soil and groundwater to levels that do not pose a risk to human health or the environment. Intrinsic biodegradation results from the combined effects of several natural processes, including biodegradation, dilution, sorption, dispersion, and volatilization. For petroleum hydrocarbons, biodegradation is the most important process because it transforms contaminants into innocuous byproducts such as water and carbon dioxide, and reduces the total mass of the contaminants in the subsurface. The other processes lower the concentration of contaminants in the environment but do not reduce their mass.

In intrinsic biodegradation, no actions are taken to enhance the biodegradation of contaminants beyond the existing capacity of the system. Intrinsic biodegradation is implemented by demonstrating that the native microbial populations have the potential to reduce contaminant levels to meet remediation goals and monitoring to confirm that contaminants do not reach areas of potential concern at unacceptable concentrations. Site owners interested in accomplishing cost-effective remediation should consider intrinsic biodegradation before investing in more aggressive alternatives that may be unnecessary for the site.

Intrinsic biodegradation has several advantages over conventional remediation methods for petroleum contaminants:

- It is less costly than conventional engineered technologies such as pump and treat - the maximum cost for intrinsic biodegradation is expected to be around $200,000 for most sites, whereas the cost of pump and treat can easily reach several million dollars.

- Minimal technical issues require resolution compared to conventional aboveground treatment requiring, for example, disposal of treated groundwater, compliance with stringent effluent guidelines, or removal of nontoxic compounds from the groundwater that interfere with treatment.

- It is nonintrusive, does not interfere with ongoing site operations, and can be used in inaccessible locations (e.g., below buildings).

- Remediation takes place in situ (i.e., in place), reducing the potential for exposing site workers to contamination.

- With no operations and maintenance requirements other than monitoring, there are no limitations such as equipment failure.

- It can be used in conjunction with conventional remedial technologies such as pump and treat.

- Microorganisms ultimately reduce petroleum contaminants to harmless byproducts, whereas some technologies transfer contaminants to other locations or other phases in the environment.

The principal limitations of intrinsic biodegradation are as follows:

- Prevailing site conditions must be suitable to support sufficient microbial activity so that contaminant concentrations are reduced to acceptable levels before potential receptors are affected.

- It may not be an appropriate stand-alone remediation option when exposure pathways are already completed or receptors are already impacted.

- Site remediation to regulatory standards generally cannot be accomplished in very short time frames.

C. SCOPE OF WORK

The scope of work for this project is presented below for the bioventing and natural attenuation portions of this study.

1. Bioventing

The scope of work for bioventing included predemonstration site characterization, implementation of the technology demonstration, and demobilization from the site. The major tasks in completing the current scope of work are listed below:

- Task I involved site characterization and included measurement of initial depths to groundwater and free product, initial soil sampling, soil-gas sampling, and in situ respiration testing.

- Task II involved system installation and immediately followed Task I.

- Task III consisted of the determination of a mass balance on the bioventing test site and was conducted during Task IV.

- Task IV included system operation and maintenance.

2. Natural Attenuation

The original scope of work for natural attenuation included preliminary data evaluation and implementation of the natural attenuation study. The major tasks for completing the original scope of work are listed below. Due to the scope reduction in 1997, tasks IV and V were eliminated. Rather than implementing natural attenuation, a preliminary evaluation was performed to determine if natural attenuation would be an effective remedial technology at this site. Based on the preliminary evaluation, recommendations are made concerning the implementation of natural attenuation.

- Task I involved review of existing site data to determine the potential feasibility of natural attenuation.

- Task II involved development of a preliminary conceptual model to better assess the potential for natural attenuation and to evaluate the potential for the plume to enter exposure pathways or to exceed regulatory guidelines.

- Task III involved a site characterization.

- Task IV would have involved refinement of the conceptual model, pre-modeling calculations, and numerical modeling of natural attenuation.

- Task V would have involved development and implementation of a long-term monitoring program.

SECTION II
SITE DESCRIPTION

This section presents information on the test site located at Rhein-Main Air Base. The information presented here includes the current understanding of site geology, hydrogeology, and contaminant distribution at the Petroleum, Oil, and Lubricants (POL) Yard located at Rhein-Main Air Base, Germany.

A. SITE LOCATION AND HISTORY

The bioventing test site was located at the POL Yard at Rhein-Main Air Base (Figure 1). Rhein-Main Air Base is an active air base located just outside Frankfurt, Germany. The 469th Air Base Squadron is Rhein-Main's host unit. Its mission is to maintain an infrastructure ready for major airlift contingencies and to provide Base operating support.

The test site is in a POL Yard and is located near an underground pipeline that was used to transfer fuel from underground storage tanks (USTs) to vehicles. The tanks have contained primarily diesel fuel, although it is believed that jet fuel also was stored in them periodically. The pipeline and USTs have since been removed.

B. HYDROGEOLOGIC CHARACTERISTICS

The surficial geology in the vicinity of the Rhein-Main Air Base consists primarily of Quaternary sands and gravels with interbedded layers of silt. These deposits form a surficial aquifer that has been contaminated by fuel products in the POL Yard of Rhein-Main Air Base.

The primary surface water body in the area is the Main River, located approximately 5.4 km (3.3 miles) downgradient from the POL Yard. No major surface water features are present in the immediate vicinity of Rhein-Main Air Base. Consequently, there is little to no surface runoff. The annual precipitation for the time period 1891 through 1955 ranged between 590 to 660 mm/year (23 to 26 inches/year). Evaporation rates for the same time period were approximately 430 to 450 mm/year (17 to 18 inches/year). Consequently, an annual recharge rate of 160 to 210 mm/year (6.3 to 8.3 inches/year) can be expected for this area (Hessiches Landesamt für Bodenforschung, 1980).

An unconfined aquifer exists at approximately 7.5 to 8.0 m (25 to 26 ft) below ground surface (bgs) at the site. The saturated thickness of the aquifer is approximately 40 m (130 ft). The direction of groundwater flow in the vicinity of the POL Yard is to the northwest, toward the Main River. Groundwater flows at a rate of approximately 0.12 m/day (0.39 ft/day), with a hydraulic gradient of approximately 0.0017. The aquifer materials are highly permeable with an average representative hydraulic conductivity of approximately 2×10^{-4} m/s (6.6×10^{-4} ft/s).

Depth to groundwater has fluctuated significantly during the past 20 years due to changes in local water usage (Figure 2). In 1972, the depth to groundwater was measured at approximately 8.7 m (29 ft) bgs and dropped to approximately 10 m (33 ft) bgs in 1977. Recent measurements have shown groundwater at a depth of approximately 6.2 m (20 ft).

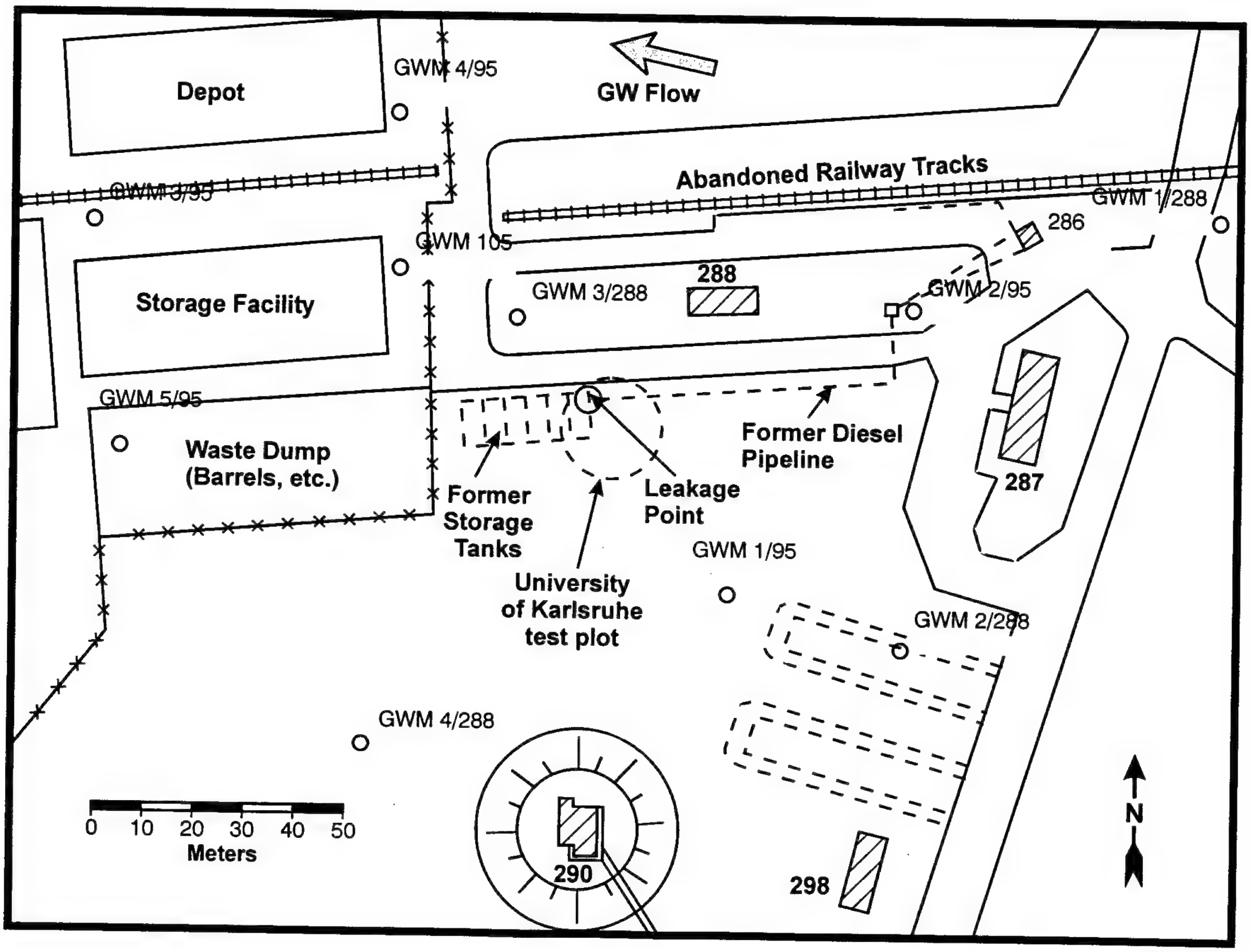

Figure 1. **Schematic Diagram Showing Monitoring Well Locations at the POL Yard, Rhein-Main Air Base Germany**

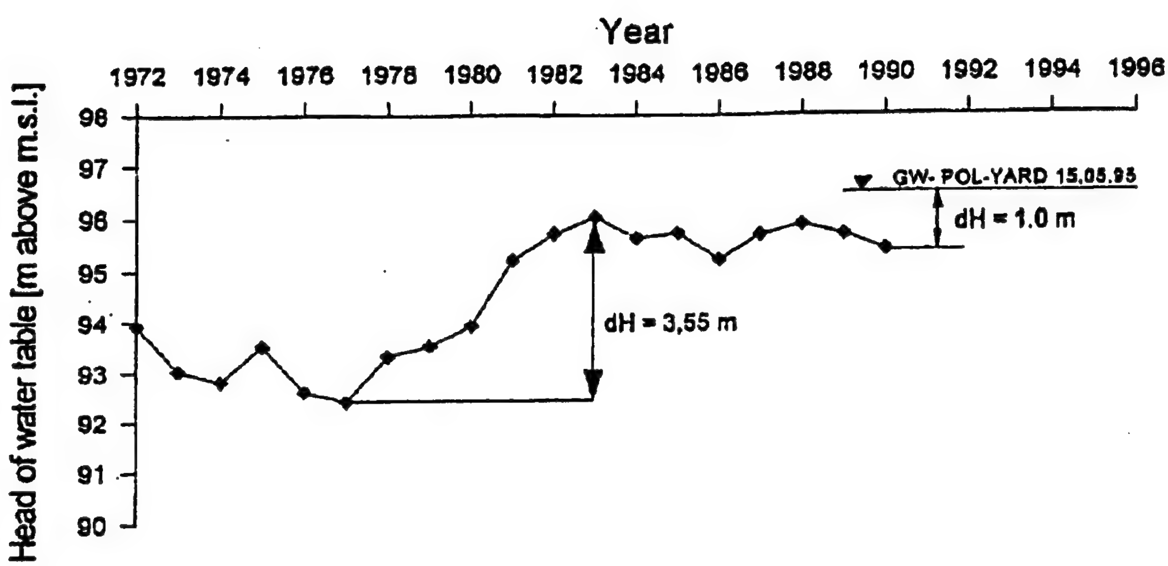

Figure 2. **Water Table Fluctuations, 1972 through 1995, Approximately 2 km from the POL Yard**

SECTION III
BIOVENTING DEMONSTRATION

This section details the activities associated with the bioventing demonstration. Included in this section is a discussion of site characterization activities, installation details, and results of field tests.

A. SITE CHARACTERIZATION

This section details the initial site characterization conducted at the bioventing test plot. Site characterization activities included an initial soil-gas survey, an in situ respiration test, and initial soil and soil-gas analyses. The results of these activities are described in the following subsections.

1. Soil-Gas Survey

A two-part soil-gas survey was conducted during November and December 1995. The first survey was conducted by collecting soil-gas samples from existing soil-gas monitoring points installed by the University of Karlsruhe earlier in 1995 (Figure 3). A schematic diagram showing construction details of a soil-gas monitoring point is provided in Figure 4. The second part of the soil-gas survey was conducted in December 1995 at a location east of the permanent soil-gas monitoring points, as shown in Figure 3. These soil gas samples were collected using the soil gas survey techniques described in Downey and Hall (1994). Soil-gas concentrations of oxygen and carbon dioxide were measured using a GasTech O_2/CO_2 meter Model 32520X, and total petroleum hydrocarbon (TPH) concentrations were measured using a GasTech TraceTechtor Vapor Analyzer.

Oxygen, carbon dioxide, and TPH concentrations measured during the initial soil-gas survey are shown in Table 1. Oxygen limitation was observed at nearly all depths, with oxygen concentrations generally decreasing with depth. Low oxygen concentrations correlated with high carbon dioxide and elevated levels of TPH. The highest contaminant levels were detected in soil-gas monitoring points located on the University of Karlsruhe test plot. Soil-gas samples could not be collected from depths below 6.1 m (19 ft), because these monitoring points were at or below the groundwater table. A background, uncontaminated area also was identified during the initial soil-gas survey and was located approximately 17.7 m (58.07 ft) east of the northeast corner of Building 329 outside of the POL Yard. The uncontaminated area was characterized by relatively high oxygen, low carbon dioxide, and little to no TPH in soil gas.

The second soil-gas survey was conducted further east of the permanent soil-gas monitoring points in an attempt to locate a contaminated area for the bioventing system beyond the radius of influence of the University of Karlsruhe test plot. Eight soil-gas survey points were located in a grid-like fashion, and one point was located in the median (Figure 3). Stainless steel soil-gas probes (KV Associates) were driven to several depths at each location, and a volume of soil gas was collected with a vacuum pump from each depth for analysis. The samples were analyzed for oxygen, carbon dioxide, and TPH concentrations.

Soil-gas samples were collected approximately every meter (3.3 ft) to a depth of approximately 5 m (16 ft). Results from the second soil-gas survey (SGS) are shown in Table 2. Oxygen limitation was most pronounced in the areas of soil-gas survey points SGS2, SGS4, SGS5,

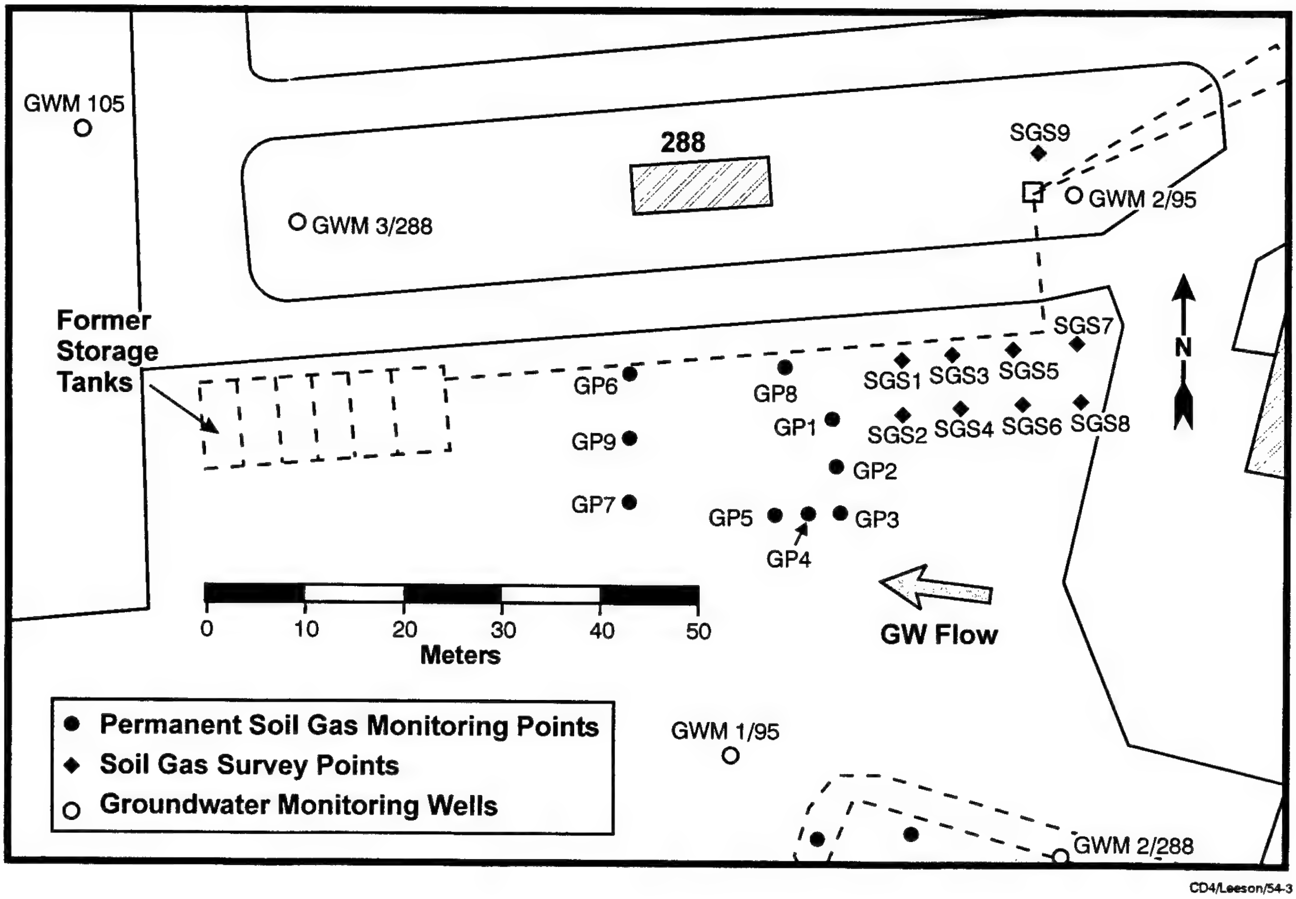

Figure 3. Schematic Diagram Showing Locations of Soil-Gas Monitoring Points and Soil-Gas Survey Points at the POL Yard

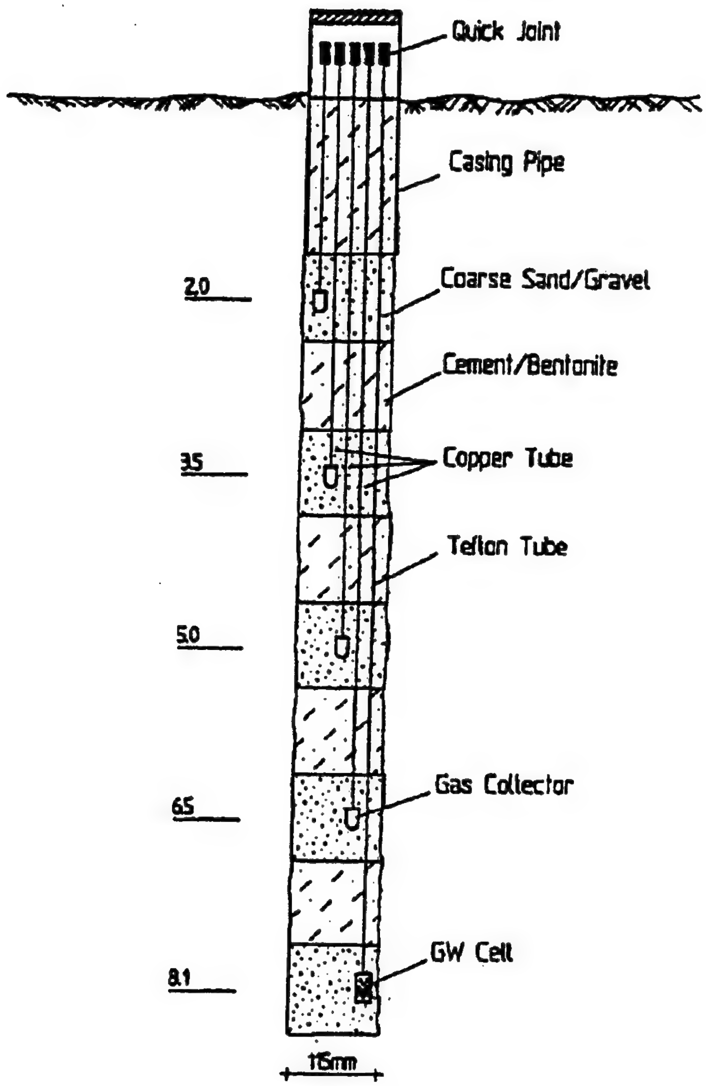

Figure 4. **Schematic Diagram of Soil-Gas Monitoring Points Installed by the University of Karlsruhe**

Table 1. Results from the Initial Soil Gas Survey at the POL Yard

Soil Gas Monitoring Point	Depth (m)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
GP1	1.8	7.0	9.2	440
	3.25	1.0	14	560
	4.8	0.5	14	1,080
	6.3	NS	NS	NS
GP2	2.5	6.0	10.5	420
	3.25	0.5	14	1,400
	4.95	0.5	15	2,400
	6.55	NS	NS	NS
GP3	2.0	6.0	13	380
	3.5	4.0	12	420
	4.95	2.0	10	420
	6.5	NS	NS	NS
GP4	2.0	16	4.5	320
	3.5	5.0	12	460
	5.0	4.0	12.6	480
	6.5	NS	NS	NS
GP5	1.85	15	5.0	320
	3.4	6.0	12	440
	4.75	6.0	11	400
	6.1	5.0	12.2	2,200

Table 1. Results from the Initial Soil Gas Survey at the POL Yard (continued)

Soil Gas Monitoring Point	Depth (m)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
GP6	2.0	1.5	13	>10,000
	3.5	2.8	13	>10,000
	5.0	2.8	10	>10,000
	6.6	NS	NS	NS
GP7	2.0	10	9.1	1,080
	3.5	2.0	13	2,000
	5.0	2.0	5.2	16,400
	6.5	NS	NS	NS
GP8	2.0	7.0	9.2	440
	3.5	1.0	14	560
	5.0	0.5	14	1,080
	6.5	NS	NS	NS
GP9	2.0	2.0	12.2	640
	3.5	2.2	4.8	>10,000
	5.0	3.2	3.8	>10,000
	6.4	NS	NS	NS

NS = Not sampled. Soil gas monitoring points were located at or just below the water table, preventing collection of soil gas samples.
ppmv = parts per million by volume.
TPH = Total petroleum hydrocarbons.

Table 2. Results from the December 1995 Soil Gas Survey at the POL Yard

Soil Gas Monitoring Point	Depth (m)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
SGS1	0.90	8.3	7.7	120
	1.66	6.7	10	120
	2.42	7.4	9.1	80
	3.18	7.9	8.3	80
	3.94	2.5	11.9	160
	4.70	4.1	11.8	760
SGS2	0.90	1.0	12.5	720
	1.66	0.9	12.6	760
	2.42	0.8	12.9	760
	3.18	0.9	12.6	1,000
	3.94	1.0	12.2	1,120
	4.70	1.2	12.6	1,440
SGS3	0.90	1.6	13.3	400
	1.66	1.5	13.3	400
	2.42	2.1	12.9	500
	3.18	1.9	13.3	640
	3.94	1.1	13.7	800
	4.70	1.1	13.7	960

Table 2. **Results from the December 1995 Soil Gas Survey at the POL Yard (continued)**

Soil Gas Monitoring Point	Depth (m)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
SGS4	0.90	1.0	12.8	2,000
	1.66	0.8	12.2	2,360
	2.42	1.0	12.5	2,520
	3.18	1.0	12.9	2,760
	3.94	1.0	13.3	2,880
	4.70	1.1	13.3	3,000
SGS5	0.90	2.2	13.7	120
	1.66	0.7	14.5	120
	2.42	0.6	14.9	160
	3.18	0.6	15.3	160
	3.94	0.6	15.7	520
	4.70	0.6	15.3	1,120
SGS6	0.90	1.6	12.1	1,240
	1.66	1.3	12.6	1,440
	2.42	1.2	12.9	1,360
	3.18	1.2	12.9	1,720
	3.94	1.1	12.9	1,920
	4.70	0.9	13.7	2,200

Table 2. Results from the December 1995 Soil Gas Survey at the POL Yard (continued)

Soil Gas Monitoring Point	Depth (m)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
SGS7	0.90	8.5	8.1	40
	1.66	8.2	8.8	40
	2.42	6.4	10.5	0
	3.18	5.2	11.7	0
	3.94	4.0	12.9	0
	4.70	2.9	14.1	0
SGS8	0.90	4.3	11.2	40
	1.66	3.1	12.5	40
	2.42	2.7	13.3	40
	3.18	2.2	14.1	40
	3.94	2.5	14.1	40
	4.70	1.2	14.9	120
SGS9	0.90	17.5	2.3	20
	1.66	17.5	2.3	20
	2.42	17.1	2.8	0
	3.18	16.4	3.2	0
	3.94	16.5	3.5	20
	4.30	15.9	3.8	20

and SGS6, where areas of low oxygen corresponded to areas of high carbon dioxide and elevated levels of TPH.

Results from the two soil gas surveys indicated that both areas investigated were contaminated and contained high microbial activity. These results suggest that bioventing is likely to be a feasible remedial technology for this site.

2. In Situ Respiration Testing

An initial in situ respiration test was conducted in November 1995 to characterize microbial activity at the site. In situ respiration tests were conducted at three of the permanent soil-gas monitoring points in the tentative bioventing test location and at two permanent soil-gas monitoring points on the University of Karlsruhe test plot. Specific monitoring points selected were GP2-3.25, GP2-4.95, and GP3-4.95 in the bioventing test plot and GP6-5.0 and GP9-5.0 in the University of Karlsruhe test plot. The in situ respiration test was conducted as described in Hinchee and Ong (1992).

The initial in situ respiration test consisted of venting the soil-gas monitoring points with an air/helium mixture over time prior to startup of the bioventing system. A mixture of approximately 2% helium in air was injected into the bioventing test site monitoring points beginning on November 14, 1995. A mixture of approximately 3% helium in air was injected into the University of Karlsruhe test plot monitoring points beginning on November 16, 1995. A ½-horsepower diaphragm pump was used to saturate a zone of soil around each soil-gas monitoring point with air (flowrate of approximately 0.028 to 0.048 m^3/min [1.0 to 1.7 ft^3/min]) for 20 hours to create an aerobic environment.

After air/helium injection was completed, soil gas was measured for oxygen, carbon dioxide, helium, and TPH. Soil gas was collected periodically for 5 days, at which point the experiment was terminated. The oxygen consumption and carbon dioxide evolution measurements were used to determine the biodegradation rates.

To compare data from one site to another, a stoichiometric relationship of the oxidation of the hydrocarbon was assumed. Hexane was used as the representative hydrocarbon for the organic contaminant. The stoichiometric relationship is given by:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O \qquad (1)$$

Based on the oxygen utilization rates (%/day), the biodegradation rates in terms of mg as a hexane equivalent per kg of soil per day were computed using the equation below by assuming a soil porosity of 0.3 and a bulk density of 1,440 kg/m^3.

$$K_\beta = \frac{-K_o A \rho_o C}{100} \qquad (2)$$

where: K_β = biodegradation rate (mg/kg-day)
K_o = oxygen utilization rate (%/day)

A	=	volume of air per kg of soil, in this case 300/1,440 = 0.21
ρ_o	=	density of oxygen gas (mg/L), assumed to be 1,330 mg/L
C	=	mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1:3.5 from the above stoichiometric equation.

Results from the in situ respiration test are shown in Table 3. As expected, in situ respiration rates were higher in the University of Karlsruhe test plot than in the bioventing test plot due to higher contamination levels. Oxygen utilization rates in the bioventing test plot ranged from 0.79 to 2.1%/day, while in the University of Karlsruhe test plot the rates ranged from 2.9 to 3.4%/day. Although these rates tend to be relatively low, they still fall within the typical range of respiration rates observed at petroleum-contaminated sites.

Table 3. In Situ Respiration Rates at the POL Yard

Soil Gas Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
GP2	3.5	1.2	0.82
	5.0	2.1	1.4
GP3	5.0	0.79	0.54
GP6	5.0	3.4	2.3
GP9	5.0	2.9	2.0

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributed to either diffusion or leakage. A rapid drop in helium concentration followed by a leveling off is an indication of leakage. A gradual loss of helium along with an apparent first-order curve is an indicator of diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium gas diffuses about 2.8 times faster than does oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. In general, if helium concentrations are at least 50 to 60% of the initial levels at test completion, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative. Helium concentrations during these tests remained relatively constant, indicating that oxygen depletion was attributable to microbial activity.

3. Collection and Laboratory Analysis of Soil-Gas Samples

Soil-gas samples were collected from the bioventing test plot prior to initiating bioventing. Samples were collected from the following monitoring points: MPA-6m, MPB-2m, MPC-6m, and MPD-6m. Soil gas samples were collected in canisters prepared by Air Toxics, Inc. Each soil-gas sample was labeled according to the location and depth of the sample. The time, date sampled, and

sampler's initials were recorded on the sample label. Samples were recorded on a chain-of-custody sheet and shipped on ice to Air Toxics, Inc. for analysis. Soil-gas samples were analyzed by gas chromatography (GC) for petroleum contamination using U.S. EPA Method TO-3. The specific compounds measured were TPH, benzene, toluene, ethylbenzene, and xylenes (BTEX). Raw data from these analyses are presented in Appendix A.

4. Collection and Analysis of Soil Samples

Initial soil sampling activities were conducted in April/May 1996. One soil boring was sampled only for inorganic analyses. Five soil borings in the bioventing test plot were sampled continuously using a 2-ft-long split spoon sampler. Typically, two soil samples from each split spoon were collected for chemical analyses (sleeves 0.5 to 1.0 ft and 1.5 to 2.0 ft from the bottom of the sampler). The remaining two samples were used for boring logs. Sample sleeves being saved for analysis were capped with plastic end covers and sealed with electrical tape. Each soil sample was labeled according to boring number and sample depth. The time, date sampled, and sampler's initials were all recorded on the sample label. Samples were recorded on a chain-of-custody sheet and shipped on ice to Alpha Analytical for analysis. Soil samples were analyzed by GC for petroleum contamination using U.S. EPA Method 8015. The specific compounds measured were TPH and BTEX. Analytical results are presented in Appendix A. Boring logs are presented in Appendix B.

Approximately seven soil samples, each from a different depth, were analyzed from each test plot and the background area to determine soil characteristics. The analyses conducted included alkalinity, iron, moisture content, particle size, pH, total Kjeldahl nitrogen (TKN), total phosphorus (TP), total sulfate, and sulfide.

B. INSTALLATION DETAILS

Installations took place in the test plot and at a background area at Rhein-Main Air Base. A schematic diagram of the entire site is shown in Figure 5. The test site was installed with the northern portion over an area where a subsurface petroleum line had been located. The petroleum line was used to fill underground storage tanks. The tanks and lines were removed several years ago. The most highly contaminated area is located under the excavated tanks; however, this area could not be used for the demonstration, because it is already being used for the University of Karlsruhe's demonstration.

Brief descriptions of the construction details of each installation in the test plot are given in the following subsections. A schematic diagram showing a plan view of the test plot is shown in Figure 6.

1. Construction Details of Vent Wells

Four vent wells were installed in the bioventing test plot. A schematic diagram showing a cross section of the vent wells is shown in Figure 7. All vent wells were installed with a solid-stem auger. Once the water table was reached, a gravel pump was used to advance the borehole. A casing was advanced to the desired depth, and the vent well was installed inside the casing. The casing was removed from the borehole as the vent well was completed (i.e., once the sand pack was in place). The 2-inch-diameter vent wells were installed to a depth of approximately 10 m (33 ft) with approximately 6 m (20 ft) of 10-slot schedule 40 polyvinyl chloride (PVC) screen and 4.5 m (15 ft)

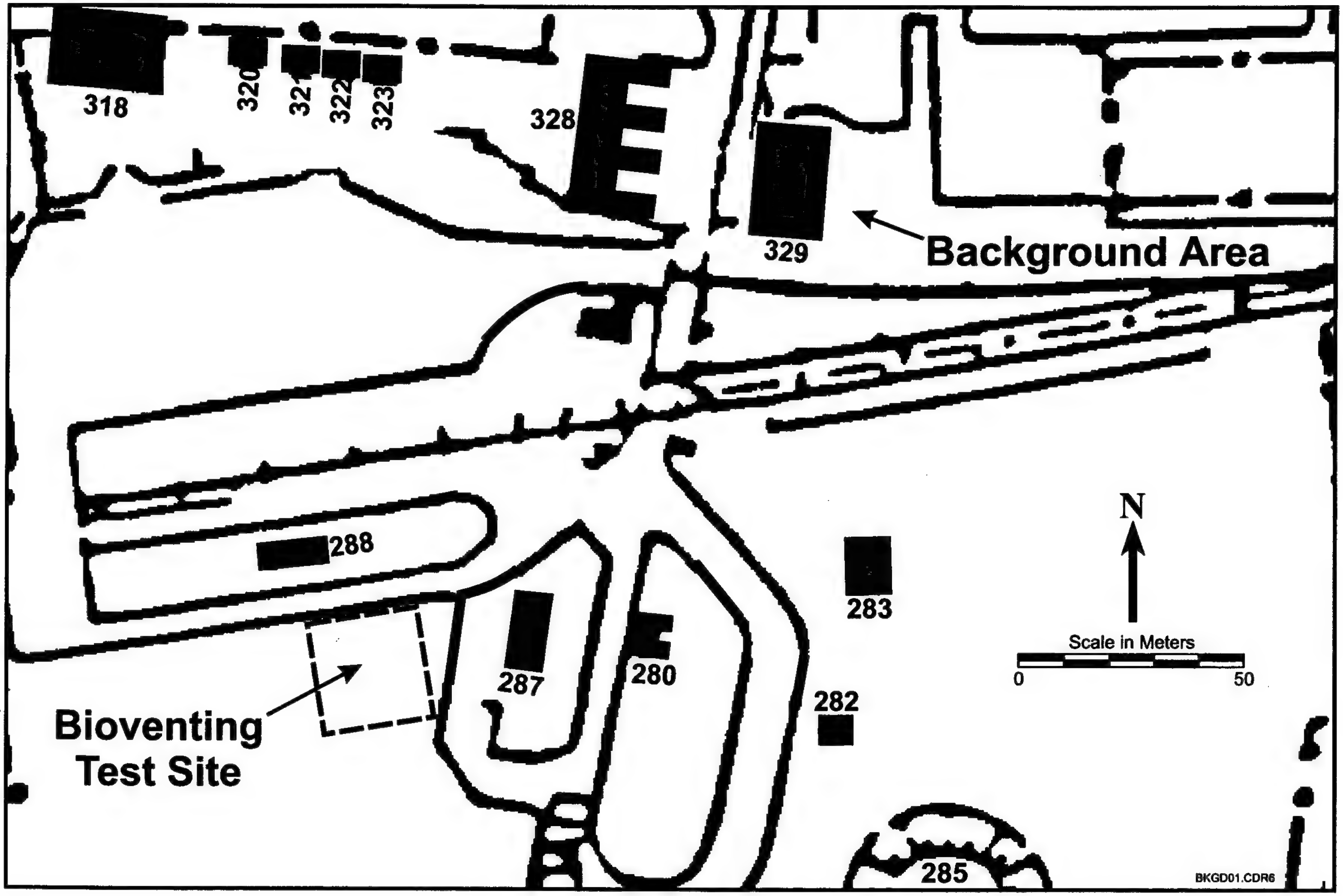

Figure 5. Schematic Diagram Showing Locations of the Bioventing Test Plot and Background Area at the POL Yard

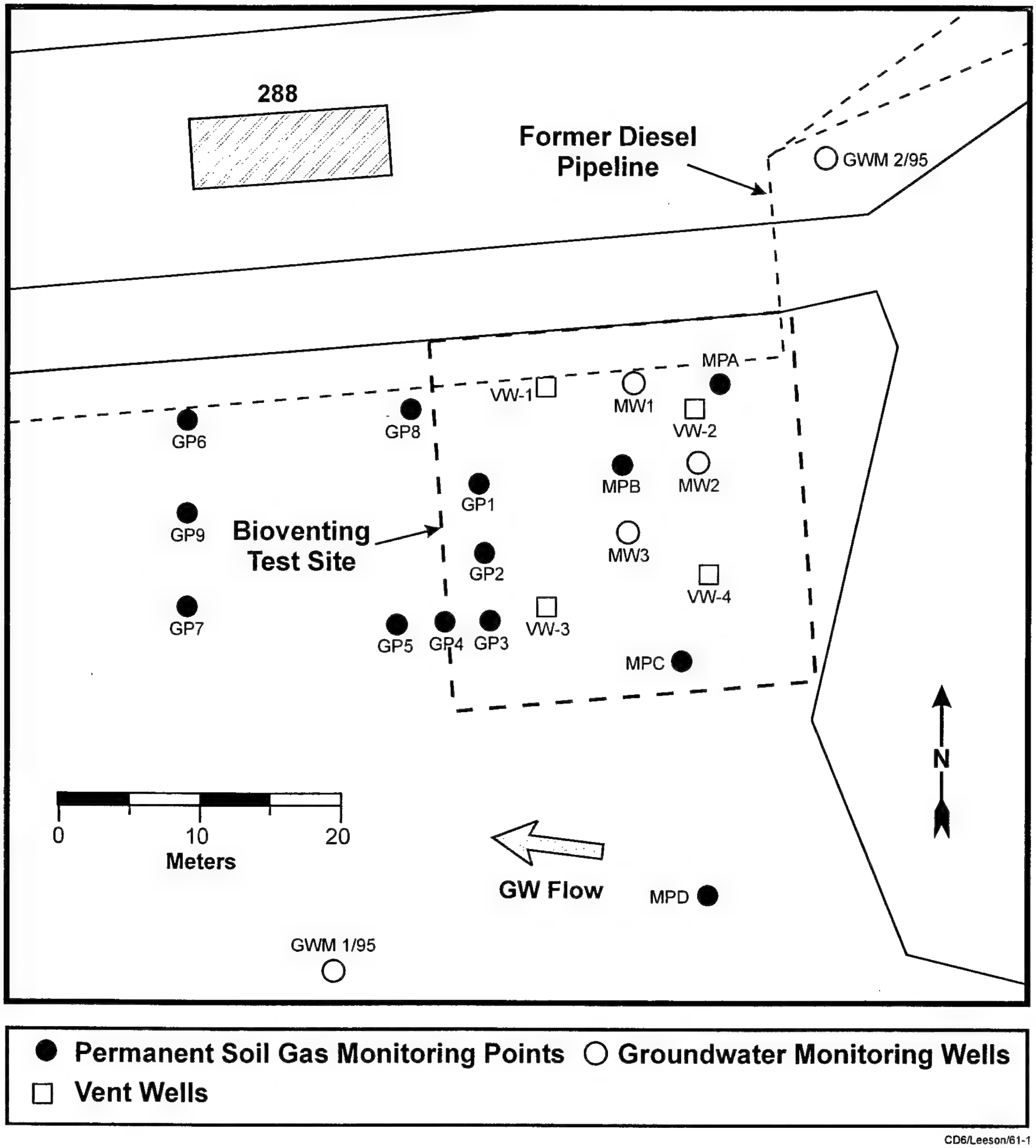

Figure 6. Plan View of the Bioventing Test Plot Showing Locations of Vent Wells, Soil-Gas Monitoring Points, and Groundwater Monitoring Wells

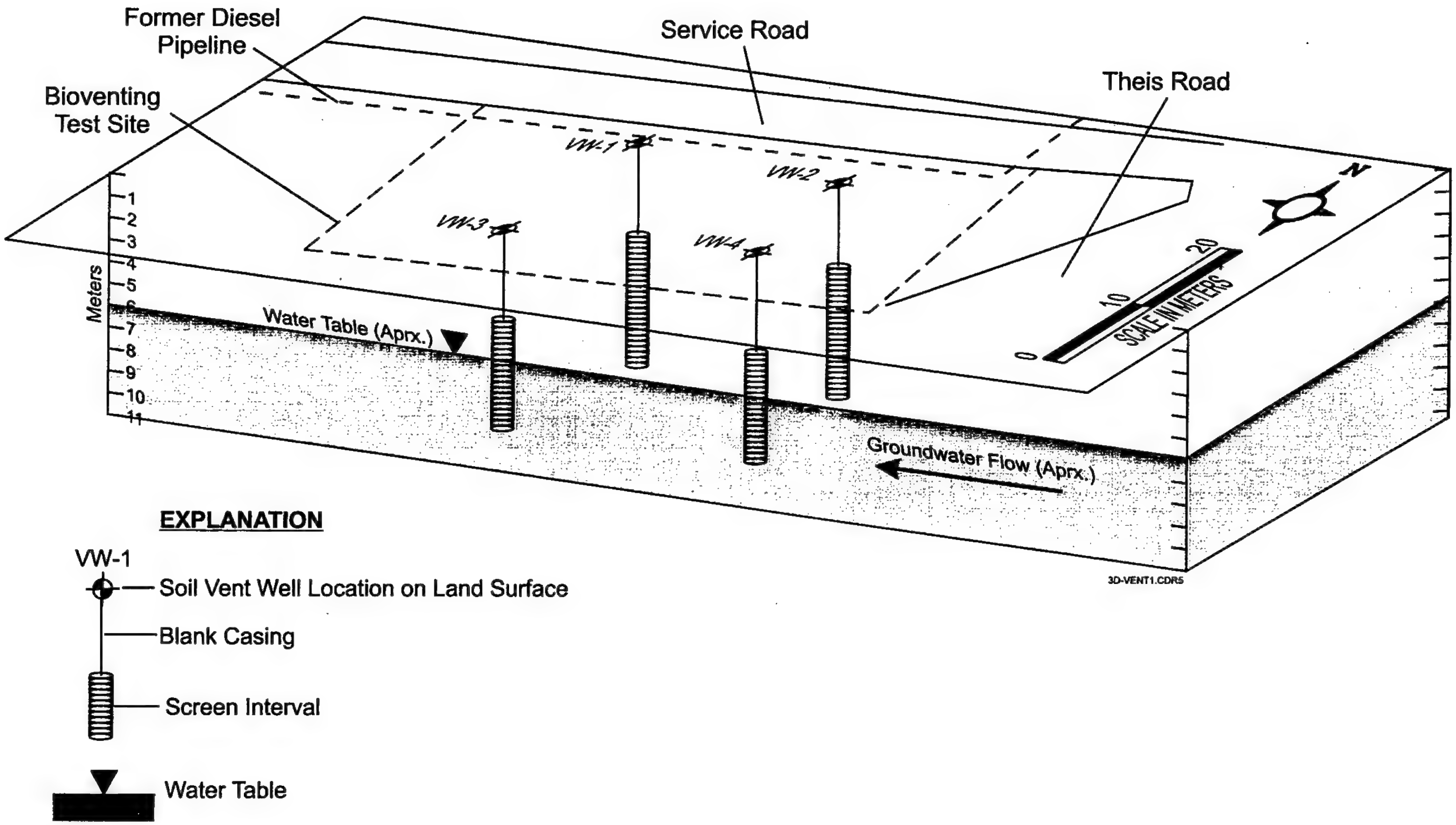

Figure 7. Schematic Diagram Showing Cross Section of Vent Wells at the Bioventing Test Plot

of PVC casing finished 0.5 m (1.6 ft) above grade. Specific construction details are shown in Table 4. A medium-grade silica and filter pack was installed across the screened interval, and bentonite chips were used to fill the remaining annular space to grade.

2. Construction Details of Soil-Gas Monitoring Points

Four eight-level soil gas monitoring points were installed using a truck-mounted drill rig equipped with a 6-inch inside diameter solid-stem auger. Below the water table, the borehole was advanced as described in Section III.B.1. The monitoring points consisted of several ¼-inch-diameter polyvinyl tubes to the specified depth attached to a screen approximately 6 inches long and 1 inch in diameter. All screened intervals were placed in the same borehole in the center of a sand filter pack. A bentonite chip vapor barrier was used to fill the remaining space between the screened intervals. Screened intervals were installed at each monitoring point with the bottom of the screen located at the following depths: 1, 2, 3, 4, 5, 6, 7, and 8 m. All screened intervals were color-coded, with colored polyvinyl tubing associated with a specific depth, as follows: clear = 1 m; black = 2 m; brown = 3 m; green = 4 m; orange = 5 m; red = 6 m; yellow = 7 m; and blue = 8 m. A schematic diagram depicting cross sections of all monitoring points is shown in Figure 8.

Type K thermocouples were installed with monitoring points MPB, MPC, and MPD. Thermocouples were installed with all screened intervals at monitoring point MPB; at depths of 2, 4, 6, and 8 m at monitoring point MPC; and at depths of 1, 4, and 6 m at monitoring point MPD.

3. Construction Details of Groundwater Monitoring Wells

A schematic diagram depicting a cross section of the groundwater monitoring wells is shown in Figure 9. Three 2-inch-diameter PVC groundwater monitoring wells were installed using a truck-mounted drill rig with a solid-stem auger. Below the water table, the borehole was advanced as described in Section III.B.1. Monitoring well MW1 was installed to a depth of 10.5 m (34 ft) with 1 m (3.3 ft) of 10-slot screen and 10 m (3 ft) of schedule 40 PVC casing. Monitoring wells MW2 and MW3 were installed to a total depth of 9.5 m (31 ft) with 1 m (3.3 ft) of 10-slot screen and 9.0 m (30 ft) of casing. The annular space outside the screened interval of the monitoring wells was filled with a medium-grade silica sand filter pack. The remaining annular space was sealed to the surface with a bentonite plug. Specific construction details for each monitoring well are shown in Table 4.

4. Background Area Soil-Gas Monitoring Point

An uncontaminated area was located approximately 300 ft northeast of the bioventing test site. One soil-gas monitoring point was installed to a depth of 8 m with 8 screened intervals. The monitoring point was constructed as described in Section III.B.2, with the bottom of the screened intervals at depths of 1, 2, 3, 4, 5, 6, 7, and 8 m. Screened intervals were color-coded as described in Section III.B.2.

5. System Operation

The bioventing system consists of a regenerative air blower plumbed to the air injection (vent) wells in the test plot. Operation of the bioventing system involved introducing oxygen into the vadose zone by injecting atmospheric air into the contaminated subsurface with the blower. Air was injected at a rate of 350 L/min (12.5 cfm) into each vent well beginning in June 1996.

Table 4. **Drilling and Completion Summary for Installations at the Bioventing Test Plot, POL Yard**

Well Name	Date Drilled	Date Completed	Total Depth (m)	Screen Interval (m)
VW-1	04/02/96	04/03/96	10.10	4.1-10.1
VW-2	04/09/96	04/10/96	9.80	3.8-9.8
VW-3	04/01/96	04/02/96	9.00	4.0-9.0
VW-4	04/04/96	04/05/96	9.50	4.5-9.5
MPA	04/12/96	04/12/96	10.00	1-8[a]
MPB	04/15/96	04/16/96	10.00	1-8[a]
MPC	04/16/96	04/17/96	10.00	1-8[a]
MPD	04/17/96	04/18/96	10.00	1-8[a]
MW1	04/10/96	04/11/96	10.50	9.5-10.5
MW2	04/18/96	04/19/96	9.50	8.5-9.5
MW3	04/22/96	04/23/96	9.50	8.5-9.5
MP-Bkgd	04/23/96	04/24/96	10.00	1-8[a]

[a] Screened intervals were installed every meter.

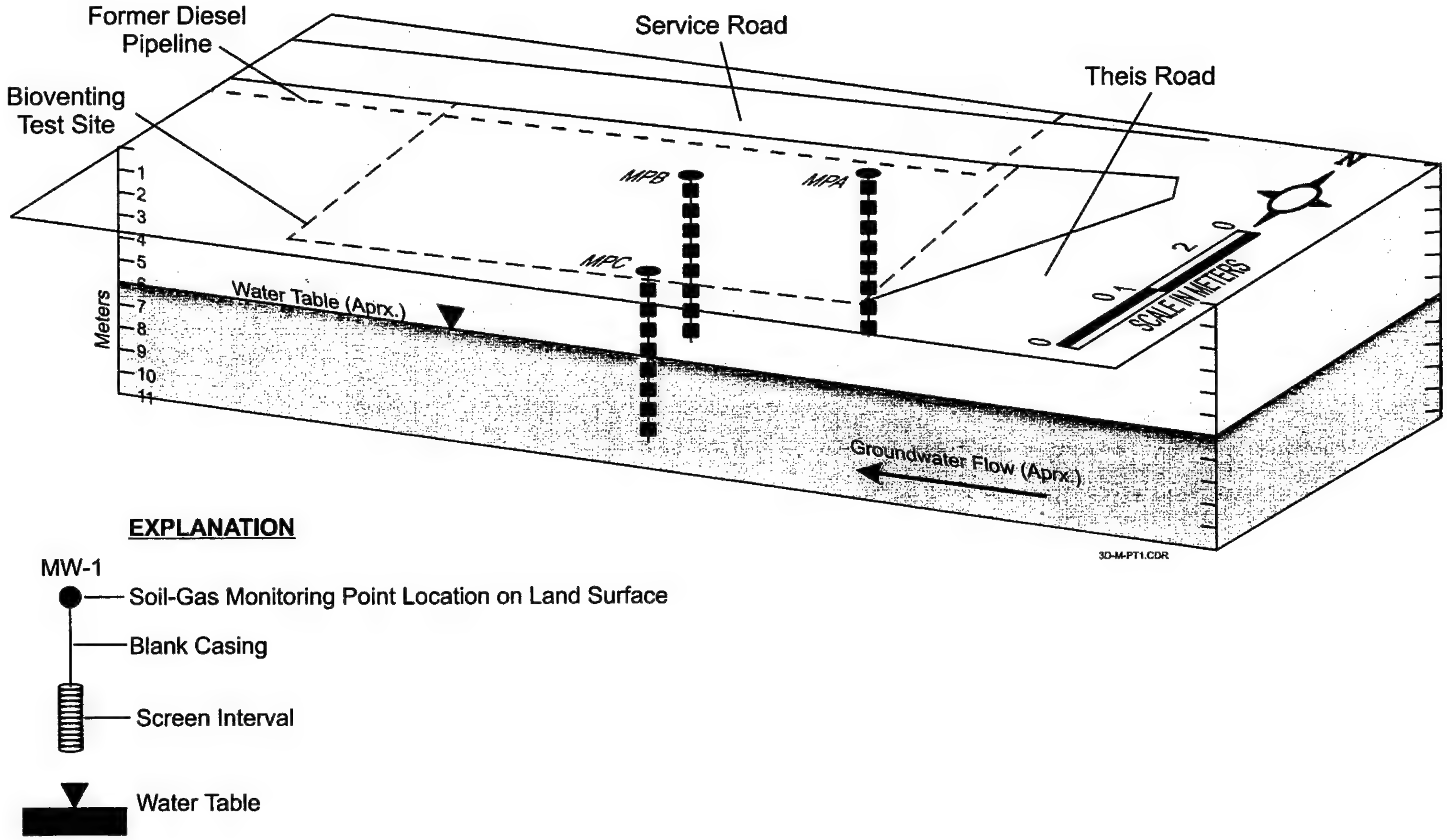

Figure 8. Schematic Diagram Showing Cross Section of Soil-Gas Monitoring Points in the Bioventing Test Plot

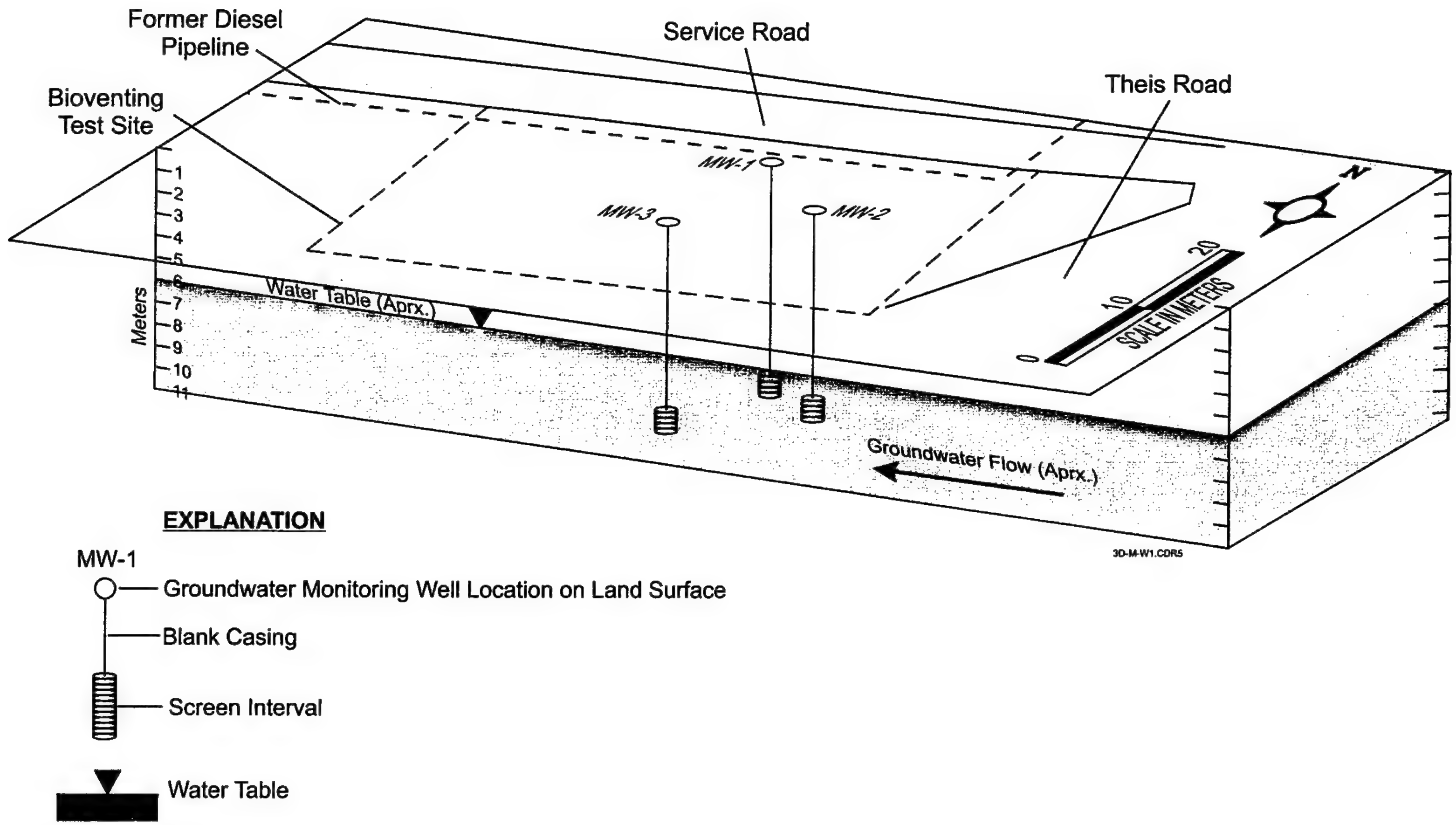

Figure 9. Schematic Diagram Showing Cross Section of Groundwater Monitoring Wells at the Bioventing Test Plot

In December 1997, the regenerative air blower was replaced with an oil-less air compressor. A ¼-inch (0.64 cm) tube was placed in monitoring well MW1 at a depth of 8.8 m (29 ft) bgs and connected to the oil-less air compressor. The compressor was started and ran until it reached equilibrium. The flowrate reached 196 L/min (7.0 cfm) at a pressure of 24 psi (165 kP). The pressure at the monitoring well was 0.35 bar.

C. METHODS FOR FIELD TESTS AND SYSTEM MONITORING

The field tests conducted for this project to date consisted of (1) surface emissions testing; and (2) soil-gas permeability testing. System monitoring included regular field soil-gas sampling, soil temperature analysis, and in situ respiration tests. Methods used for the field tests and system monitoring are described in the following subsections.

1. Surface Emissions Testing

One of the concerns about bioventing as a means of soil remediation is the possibility of transferring soil contaminants to the atmosphere through air-stripping of organics. To determine if there is any significant release of volatile organic compounds (VOCs) to the atmosphere during bioventing, surface emissions testing was performed. The sampling and analytical methodologies for these tests are presented in the following subsections.

a. Dynamic Surface Emissions Sampling Methodology

A dynamic surface emissions sampling methodology was used at Rhein-Main Air Base. This method involved enclosing an area of soil under an inert box designed to allow the purging of the enclosure with high-purity air (Dupont, 1987). The box was purged for two hours to remove ambient air from the region above the soil and to allow an equilibrium to be established between the hydrocarbons emitted from the soil and the organic-free air. The air stream was then sampled by drawing a known volume of the hydrocarbon/pure air mixture through a tube packed with sorbent materials. The sorbents retained any organics associated with surface emissions. The sample tube was thermally desorbed, and the organics were resolved and quantified by GC. These measured concentrations were then used to calculate the emission rates for the hydrocarbons from the soil to the atmosphere.

A schematic diagram of the surface emissions sampling system is shown in Figure 10. The system consisted of a square Teflon® box that covered a surface area of 0.45 m^2. The box was fitted with inlet and outlet ports for the entry and exit of high-purity air. Inside the box was a manifold that delivered the air supply uniformly across the soil surface. The same type of manifold was fitted to the exit port of the box. This configuration delivered an even flow of air across the entire soil surface under the box so that a representative sample was being generated. To collect the sample, the air exiting the box was pulled through a sorbent tube by an SKC personal monitoring pump, Model #224-PCXR7.

In all cases, a totally inert system was employed. Teflon® tubing and stainless steel fittings assured that there was no contribution to or removal of organics from the air stream. The pump was located on the back side of the sorbent trap so that it was not in a position to contaminate the sample flow.

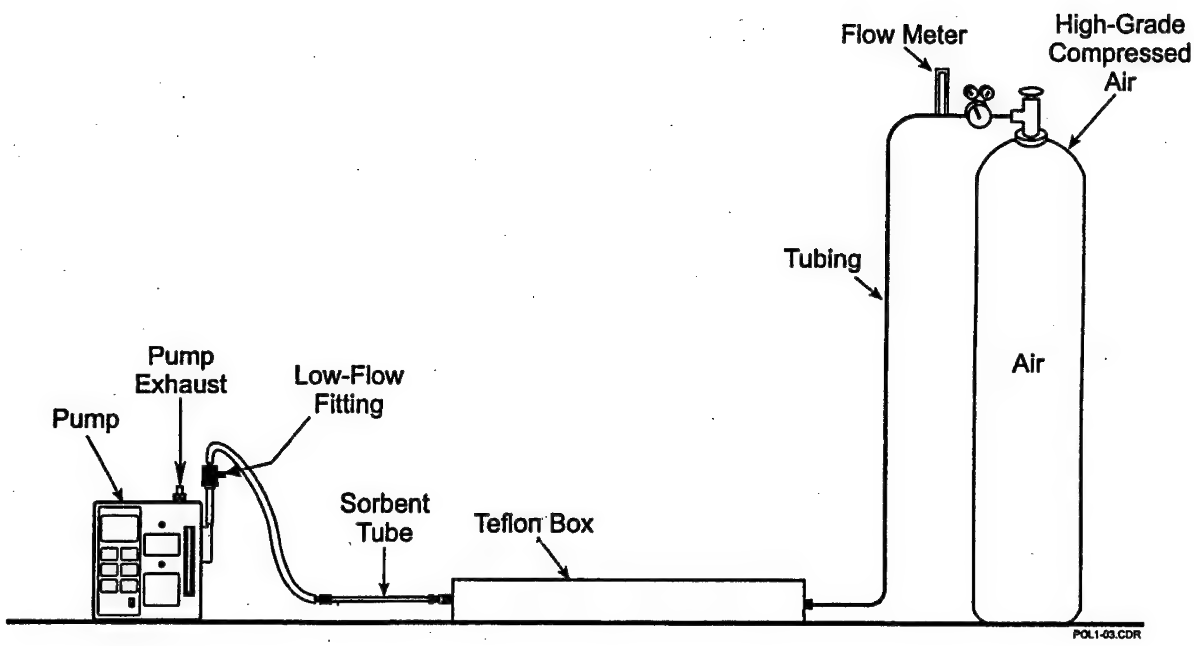

Figure 10. Schematic Diagram of the Surface Emissions Sampling System

Sample results and analytical precision are presented in Appendix C.

b. Sampling Schedule

Two surface emission sampling events were performed at the bioventing site at Rhein-Main Air Base during 1996, and a final surface emission sampling event was performed in 1998. Sampling conditions for each of the sampling events are described in the following subsections.

i. April 1996. The April sampling event was the first time that the dynamic surface emissions methodology was used at Rhein-Main Air Base. This sampling event was used to generate an initial data set for surface emissions prior to initiating bioventing. General sampling locations at the center and perimeter of the test plot, as well as at a background location, were identified (Figure 11). Air was pulled through the sorbent tube at a flowrate of 50 mL/minute over a 6-minute interval, resulting in a 300-mL sample volume.

Samples were collected at the center and perimeter of the test plot as well as at a background location prior to air injection. Triplicate samples were collected at the center and perimeter locations. At the background location, duplicate samples were collected from the area east of Building 329. In addition, one ambient air sample, one cylinder air sample, and one trip blank were analyzed. During this sampling period, the Teflon® box was positioned directly upon the soil surface.

ii. October 1996. During October/November 1996, samples were taken from the center and perimeter of the test plot both with and without air injection and also from the background location. Similar to the April sampling event, a flowrate of 50-mL/minute for 6 minutes was used to produce a 300-mL sample volume. Duplicate samples were collected at each location. A sample of the high-grade air also was collected to verify the cleanliness of the purge gas. A trip blank was reserved to identify any background artifacts from the sorbent materials. During this sampling period, the Teflon® box was positioned directly upon the soil surface.

iii. August 1998. During August 1998 the dynamic surface emissions methodology was used at Rhein-Main Air Base to perform a final sampling event. Samples were taken from the center and perimeter of the test plot both with and without air injection and also from the background location. Similar to previous sampling events, a flowrate of 50-mL/minute for 6 minutes was used to produce a 300-mL sample volume. Duplicate samples were collected at each location. A sample of the ambient air and a trip blank were included in the sampling protocol for the reasons identified in the description of the October 1996 sampling event. Unlike the May 1996 and October 1996 sampling events, a stainless steel box rather than a Teflon® box was used for surface emission testing. Both stainless steel and Teflon® are inert materials, therefore sample results should not be affected by the various construction materials of the surface emission testing box.

c. Analytical Calculations

The complete analytical data results from the surface emissions sampling at Rhein-Main Air Base are presented in Appendix C. These data are presented temporally, reflecting the two sampling events at the site. For each of these events, the following data were generated:

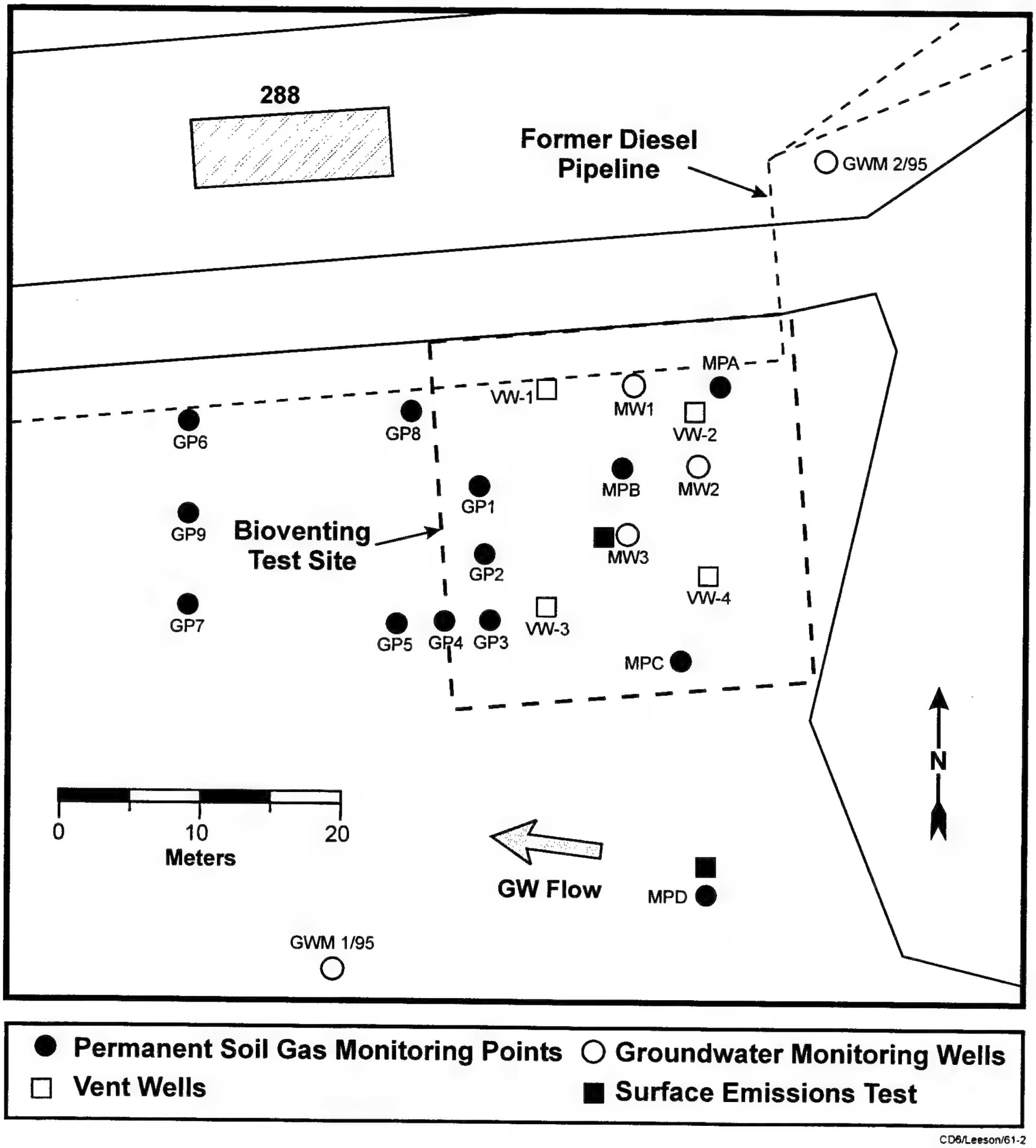

Figure 11. Locations for Surface Emissions Testing at the Bioventing Test Plot

- Flux values in μg compound emitted into the atmosphere per 0.45 m^2 per minute. These data reflect the mass of each of the BTEX compounds that were emitted from the soil during the bioventing activities.

- Results from the analysis of the sorbent tubes that were used as trip blanks, purge air blanks, and ambient air samples. The trip blanks were used to identify artifact occurrences that could have led to elevated values for the BTEX compounds and the TPH values. The cylinder air blank samples were used to confirm the quality of the purge gas and to show that this air source was not affecting the reported values for the BTEX species. The ambient air samples were collected as reference concentrations of the emission levels to the existing air quality.

- GC calibration data so that the precision of the sampling/analytical method and the instrument itself could be determined.

To calculate the actual emission rates of organic compounds from the soil surface into the atmosphere, the following formula for dynamic enclosure techniques was employed (McVeety, 1991):

$$F = \frac{CV_r}{S} \tag{3}$$

where: F = flux in mass-area/time ($\mu g \cdot m^2/min$)
C = the concentration of the gas in units of mass/volume ($\mu g/m^3$)
V_r = volumetric flowrate of sweep gas (m^3/min)
S = soil surface covered by enclosure (m^2)

2. Soil-Gas Permeability Testing

a. Soil-Gas Permeability and Radius of Influence

Soil-gas permeability, or intrinsic permeability, can be defined as a soil's capacity for fluid flow, and varies according to grain size, soil uniformity, porosity, and moisture content. The soil-gas permeability value is a physical property of the soil; it does not change with different extraction/injection rates or different pressure levels. Soil-gas permeability generally is expressed in the units cm^2 or darcy (1 darcy = 1×10^{-8} cm^2). As with hydraulic conductivity, soil-gas permeability may vary by more than 1 order of magnitude on the same site due to soil variability.

The radius of influence, is defined as the maximum distance from the air extraction or injection well where measurable vacuum or pressure (soil-gas movement) occurs. The radius of influence is a function of soil properties, but also is dependent on the configuration of the venting well and extraction or injection flowrates, and is altered by soil stratification. On sites with shallow contamination, the radius of influence can be increased by impermeable surface barriers such as asphalt or concrete. These paved surfaces may or may not act as vapor barriers. Without a tight seal to the native soil surface, the pavement will not significantly impact soil-gas flow.

The bioventing research project being performed is concentrated in a small area to demonstrate the bioventing technology. Therefore, a relatively small radius of influence was

estimated for placement of vent wells. Although the conservative rationale used for placing the vent wells was sufficient for conducting the demonstration, a more cost-efficient, systematic approach must be taken when designing a full-scale bioventing system. The soil gas permeability testing described below was conducted at the POL Yard to calculate the radius of influence to help characterize the optimum well placement configuration for the design of a full-scale bioventing system.

b. Soil-Gas Permeability Test Procedures

The procedures for conducting soil-gas permeability testing are discussed in detail in the U.S. Air Force-sponsored document, *Soil Bioventing: Principles and Practice* (Leeson and Hinchee, 1996). The general procedures used are presented within this section.

A single vent well was used for the soil-gas permeability test. All other wells in the test plot were closed. Soil-gas permeability testing was conducted in air injection mode.

Soil-gas permeability testing was conducted using the bioventing system blower. Air was injected into the single vent well. Changes in soil-gas pressure were monitored over time using a Magnehelic® gauge at the soil-gas monitoring points located at different radii from the bioventing well. The tests were discontinued when no significant pressure change could be observed in any of the monitoring points.

c. Radius of Influence Calculations

At a bioventing site, the radius of influence is defined as the maximum distance from the air extraction or injection well where a sufficient supply of oxygen for microbial respiration can be delivered. We will call the radius of influence measured by increased oxygen the "oxygen radius of influence." In practice, we frequently estimate this radius by measuring a pressure radius of influence. A description of how that is done follows.

At a bioventing site, the oxygen radius of influence is the true radius of influence; however, for design purposes, we frequently use the pressure radius of influence. The pressure radius of influence is the maximum distance from a vent well where vacuum (in extraction mode) or pressure (in injection mode) can be measured. In practice, we usually use 0.1 inches of water as the cut-off pressure. In highly permeable soils, 0.01 inches of water is a better cut-off, if it can be reliably measured. There is a connection between the pressure radius of influence and the oxygen radius of influence; however, there are many variables which are not fully understood. In practice, it has been our experience that when our design procedures are followed, the oxygen radius of influence is larger than the measured pressure radius of influence, making the pressure radius of influence a reasonably conservative, rapid method for estimating the true radius of influence. The oxygen radius of influence may be determined directly by measuring the distance from the vent well at which a change in oxygen concentration can be detected. However, it may take several days to weeks for equilibrium to be reached and an accurate oxygen radius of influence to be measured. In addition, oxygen utilization rates may change, increasing or reducing the oxygen radius of influence. Therefore, if possible, it is best to measure the oxygen radius of influence at times of peak microbial activity. Alternatively, the pressure radius of influence may be determined very quickly, generally within 2 to 4 hours. Therefore, the pressure radius of influence typically is used to design bioventing systems.

The pressure radius of influence may be estimated by determining pressure change versus distance from the vent well. The log of the pressure is plotted versus the distance from the vent well. The radius of influence is that distance at which the curve intersects a pressure of 0.1 inches H_2O (25 Pa). This value was determined empirically from U.S. Air Force Bioventing Initiative sites. The raw data from the soil-gas permeability test is provided in Appendix D.

3. Soil-Gas and Temperature Measurements

The soil gas sampling was conducted approximately monthly and analyzed in the field for oxygen, carbon dioxide, and TPH. Occasionally, the soil moisture content prevented sampling from some soil-gas monitoring points; however, adequate samples could be collected from the majority of the monitoring points. Raw data from these analyses are presented in Appendix D.

4. In Situ Respiration Testing

In situ respiration tests were conducted in August 1996, November 1996, and November 1998. These tests are based on the method described by Hinchee and Ong (1992).

The in situ respiration testing consisted of monitoring soil-gas oxygen and carbon dioxide concentrations during air injection, then turning off the air injection and monitoring the oxygen and carbon dioxide concentrations periodically over time. From these measurements, oxygen consumption and carbon dioxide production were determined. The experiment usually was terminated when either the oxygen concentration of the soil gas fell below 5% or after 5 to 7 days, whichever occurred sooner. Carbon dioxide and oxygen concentrations were measured using a GasTechtor® Model 32520X. Oxygen utilization rates typically were calculated as zero order, based on the initial linear portion of the decay curve. The methods used to calculate biodegradation rates from the in situ respiration rates are described in Section III.A.2.

Oxygen and carbon dioxide concentrations measured during the in situ respiration tests are presented in Appendix F.

D. RESULTS AND DISCUSSION OF FIELD TESTS AND SYSTEM MONITORING

This section provides a presentation and discussion of the results from the various field tests that were conducted during this study, as well as a discussion of results from the system monitoring. Major conclusions from these studies are discussed in this section and are summarized in Section E.

1. Verification of Low Surface Emissions During Bioventing

One of the concerns over the implementation of bioventing as a means of soil remediation is the possibility of transferring soil contaminants to the atmosphere through air-stripping of organics. To determine if there was significant atmospheric loading of volatile petroleum contaminants during bioventing, surface emissions testing was performed.

The results from the surface emissions tests are shown in Tables 5, 6, and 7. In these tables, the emissions levels at the sampling locations from the bioventing wells have been extrapolated to reflect atmospheric loadings in kg/m^2-day and in pounds/acre-day. These extrapolations depict a

worst-case scenario, because an emissions measurement for a 0.45-m^2 surface area is being projected over a 1-acre plot.

Surface emissions of BTEX and TPH at the bioventing test plot prior to initiating bioventing were comparable to surface emissions measured just outside of the test plot and at the uncontaminated area (Table 5). The average emissions rate of benzene in the center of the test plot was 2.6E-08 kg/m^2-day (0.00023 lb/acre-day) as compared to 2.0E-08 kg/m^2-day (0.00018 lb/acre-day) just outside of the test plot and 9.8 E-09 kg/m^2-day (0.000080 lb/acre-day) at the background area. The average emissions rate for TPH in the center of the test plot was 3.6E-06 kg/m^2-day (0.032 lb/acre-day) compared to 3.0E-06 kg/m^2-day (0.027 lb/acre-day) just outside of the test plot and 3.8E-06 kg/m^2-day (0.034 lb/acre-day) at the background area.

Surface emissions measured during October 1996 allowed for comparison of emissions during injection and without injection. Surface emissions measured at this time were significantly lower than those measured during April 1996 (Table 5). In most samples, none of the BTEX components could be detected. Very little difference could be detected between samples collected during injection and without injection. In the center of the test plot no benzene, ethylbenzene, or xylenes were detected in any samples either during or without injection and only trace amounts of toluene were detected during injection. These results indicate that, at the locations sampled, the bioventing system is not creating a pronounced level of increased emissions over natural surface emissions at the site.

Surface emissions measured during the August 1998 sampling event were compared to the previous two sampling events. In general, August 1998 surface emissions were significantly lower than those measured in April 1996 (Table 5) and somewhat greater than those measured in October 1996 (Table 6). The average benzene concentrations in the center of the test plot both with and without air injection were 1.4 E-08 kg/m^2-day (0.00012 lb/acre-day) and 1.5E-08 kg/m^2-day (0.00013 lb/acre-day), respectively, which are below the initial benzene concentrations in surface emissions prior to treatment. These data also show that operation of the blower does not seem to affect surface emission concentrations of benzene in the center of the test plot. The 1998 sampling event also revealed benzene concentrations in perimeter samples collected both with and without blower operation to be less than benzene concentrations in initial surface emission samples at the site. The TPH concentrations in the center of the test plot with the blower on and off also were less than initial TPH concentrations in April 1996. The average TPH concentration of 1.8E-07 kg/m^2-day (0.00016 lb/acre-day) detected in the perimeter sample with the blower operational was considerably less than the TPH concentration of 6.0E-06 kg/m^2-day (0.053 lb/acre-day) detected at the same location without the blower operational. Although duplicate samples were collected during each sampling condition, one set of duplicate samples was adversely impacted in the laboratory. For this reason, only results for a single sorbent tube at each location are being reported. The samples collected during air injection at the center and perimeter of the test plot were analyzed twice for quality assurance purposes, since a duplicate sample was not available. Both sets of results are presented in Table 7. Concentrations detected in the trip blank sample are associated with loose fittings found on the sorbent tube upon arrival in the laboratory.

2. Soil-Gas Permeability and Radius of Influence Results and Discussion

Estimates of the soil's permeability to fluid flow and the radius of influence of venting wells provide important inputs to a full-scale bioventing design. On-site testing provides the most accurate estimate of soil-gas permeability. On-site testing also can be used to determine the radius of influence

Table 5. Surface Emissions Sampling Results at the POL Yard Prior to Initiating Bioventing: April 1996

Sample	Flux Rates (kg/m^2-day [lb/acre/day])					
	Benzene	Toluene	Ethylbenzene	*m*- & *p*-xylene	*o*-Xylene	TPH as hexane
RM1-Center-1	2.6E-08 [0.00023]	3.8E-08 [0.00034]	<1.3E-08 [<0.00011]	1.6E-08 [0.00014]	<1.3E-08 [<0.00011]	7.8E-07 [0.0069]
RM1-Center-2	2.9E-08 [0.00026]	5.8E-08 [0.00051]	<1.3E-08 [<0.00011]	2.2E-08 [0.00020]	<1.3E-08 [<0.00011]	4.9E-06 [0.043]
RM1-Center-3	2.2E-08 [0.00020]	2.6E-08 [0.00023]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	5.1E-06 [0.045]
RM1-Perimeter-1	2.6E-08 [0.00023]	6.7E-08 [0.00060]	<1.3E-08 [<0.00011]	2.6E-08 [0.00023]	ND	7.6E-06 [0.067]
RM1-Perimeter-2	2.2E-08 [0.00020]	1.9E-08 [0.00017]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	9.0E-07 [0.0079]
RM1-Perimeter-3	1.3E-08 [0.00011]	1.3E-08 [0.00011]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	5.9E-07 [0.0052]
RM1-Background-1	<1.3E-08 [<0.00011]	1.6E-08 [0.00014]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	ND	6.8E-06 [0.060]
RM1-Background-2	1.3E-08 [0.00011]	1.6E-08 [0.00014]	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	ND	8.1E-07 [0.0072]
RM1-Atmosphere	3.2E-08 [0.00028]	6.7E-08 [0.00060]	ND	1.6E-08 [0.00014]	<1.3E-08 [<0.00011]	5.0E-06 [0.044]
RM1-Cylinder	1.3E-08 [0.00011]	<1.3E-08 [<0.00011]	ND	<1.3E-08 [<0.00011]	ND	5.4E-07 [0.0048]
RM1-Trip Blank	<1.3E-08 [<0.00011]	<1.3E-08 [<0.00011]	ND	<1.3E-08 [<0.00011]	ND	3.2E-07 [0.0029]

ND = Not detected. No trace of compound was detected. Values reported as less than detection limit were detected, but in concentrations below detection limit.

RM = Rhein-Main.

Table 6. Surface Emissions Sampling Results at the POL Yard: October 1996

Sample	Flux Rates (kg/m^2-day [lb/acre/day])					
	Benzene	Toluene	Ethylbenzene	m- & p-xylene	o-Xylene	TPH as hexane
RM1-Center-1 During Injection	ND	1.6E-08 [0.00014]	ND	ND	ND	2.1E-07 [0.0019]
RM1-Center-2 During Injection	ND	<1.6E-08 [0.00014]	ND	ND	ND	1.2E-07 [0.0010]
RM1-Perimeter-1 During Injection	1.6E-08 [0.00014]	1.6E-08 [0.00014]	ND	ND	ND	4.8E-08 [0.00050]
RM1-Perimeter-2 During Injection	ND	<1.6E-08 [<0.00014]	ND	ND	ND	1.3E-07 [0.0010]
RM1-Background-1	1.6E-08 [0.00014]	ND	ND	ND	ND	9.9E-08 [0.00090]
RM1-Background-2	<1.6E-08 [<0.00014]	ND	ND	ND	ND	3.5E-08 [0.00030]
RM1-Center-3 Without Injection	ND	ND	ND	ND	ND	5.1E-07 [0.0050]
RM1-Center-4 Without Injection	ND	ND	ND	ND	ND	6.7E-08 [0.00060]
RM1-Perimeter-3 Without Injection	ND	ND	ND	ND	ND	1.7E-06 [0.015]
RM1-Perimeter-4 Without Injection	ND	ND	ND	ND	ND	3.2E-07 [0.0029]
RM1-Cylinder	ND	3.0E-07 [0.00026]	ND	ND	ND	1.2E-06 [0.011]
RM1-Trip Blank	ND	ND	ND	ND	ND	5.9E-07 [0.0053]

ND = Not detected. No trace of compound was detected. Values reported as less than detection limit were detected, but in concentrations below detection limit.

RM = Rhein-Main.

Table 7. Surface Emissions Sampling Results at the POL Yard: August 1998

Sample	Flux Rates (kg/m^2-day [lb/acre/day])					
	Benzene	Toluene	Ethylbenzene	*m*- & *p*-Xylene	*o*-Xylene	TPH as Hexane
Center During Injection	1.2E-08 [0.00011]	5.6E-08 [0.00050]	ND	ND	1.5E-08 [0.00013]	1.4E-06 [0.013]
Center During Injection	1.5E-08 [0.00013]	6.0E-08 [0.00053]	ND	ND	ND	1.4E-06 [0.012]
Perimeter During Injection	ND	8.0E-09 [0.000071]	ND	ND	ND	1.7E-07 [0.0015]
Perimeter During Injection	9.3E-09 [0.000083]	ND	ND	ND	ND	1.9E-07 [0.0017]
Background	1.1E-08 [0.00010]	3.1E-07 [0.0028]	ND	1.1E-08 [0.000095]	ND	6.4E-06 [0.057]
Center W/O Injection	1.5E-08 [0.00013]	3.5E-08 [0.00032]	ND	ND	ND	6.0E-07 [0.0053]
Perimeter W/O Injection	1.7E-08 [0.00015]	3.3E-07 [0.0029]	ND	1.1E-08 [0.000097]	ND	6.0E-06 [0.053]
Ambient Air	1.3E-08 [0.00012]	2.0E-07 [0.0018]	ND	ND	ND	5.0E-06 [0.044]
Trip Blank	8.5E-09 [0.000076]	2.5E-07 [0.0023]	ND	ND	ND	3.2E-06 [0.029]

ND = Not detected. No trace of compound was detected. Values reported as less than detection limit were detected, but in concentrations below detection limit.

that can be achieved for a given well configuration and its flowrate and air pressure. These data are used to design full-scale systems, specifically to space venting wells, to size blower equipment, and to ensure that the entire site receives a supply of oxygen-rich air to sustain in situ biodegradation. Results from the soil-gas permeability testing conducted during this study are presented in the following discussion.

The radius of influence at a particular site is a function of soil properties, but also is dependent on vent well configuration and the extraction or injection flowrates. For this study, radius of influence was defined as the radial distance from the vent well where a change of 0.1-inch water pressure could be observed. The radius of influence observed for the test plot was approximately 24 ft. The estimation of the radius of influence at the bioventing test plot is shown in Figure 12.

Pressure changes were monitored at all depths during the soil-gas permeability tests. As was expected, the values for radius of influence generally are greater at the deeper depths. This difference occurs in part because, at the shallower depths, short-circuiting of air flow to the surface can occur more rapidly. In general, the radius of influence was greater at the deeper depths, with values ranging from 4.6 m (15 ft) at a depth of 2 m (6.6 ft) up to 11 m (37 ft) at a depth of 4 m (13 ft) (Table 8).

Table 8. Radius of Influence Versus Depth at the Bioventing Test Plot, POL Yard

Depth (m)	Radius of Influence (m)
1	7.0
2	4.6
3	6.1
4	11
5	9.1
6	9.1

Radius of influence is just one factor in locating bioventing wells for optimum site coverage. Other site conditions that must be considered include location and depth of underground structures that could act as barriers or conduits to fluid flow, proximity of adjacent buildings, surface structures, and surface activities. Based on the data for the POL Yard and assuming that, in general, most of the contamination is at the deeper depths, a radius of influence of 9 m (30 ft) may be sufficient for site coverage. This would necessitate a well spacing of 18 m (60 ft). At the 18-m spacing, approximately 12 wells would be sufficient to treat more than 4,000 m^2 ($\sim$1 acre) of site surface area.

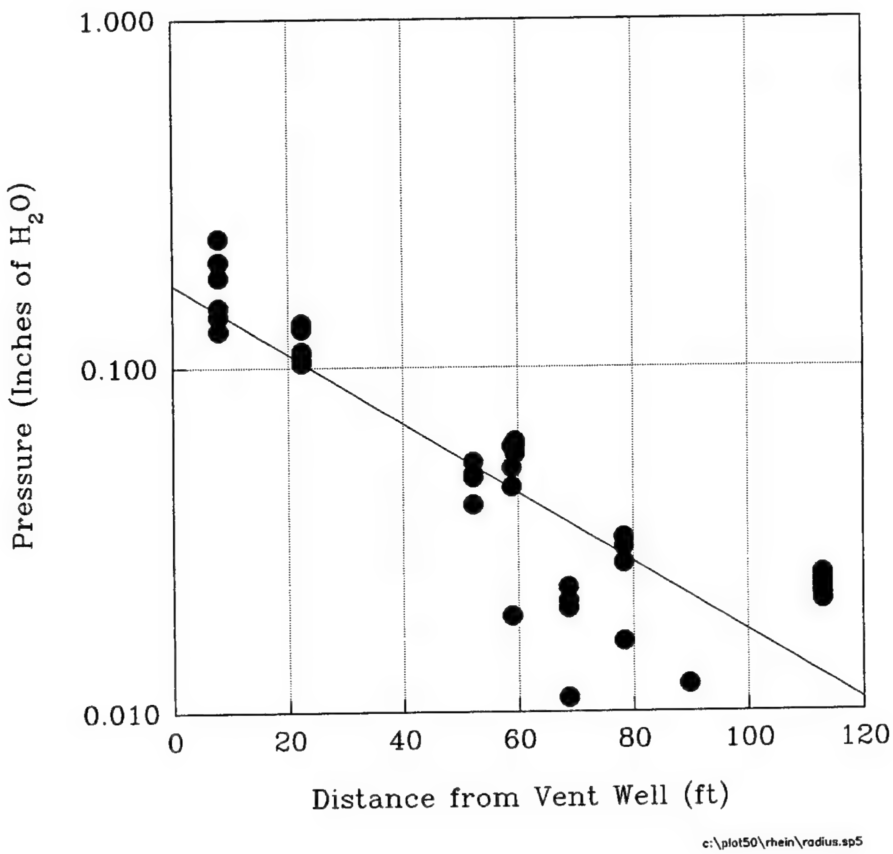

Figure 12. Radius of Influence in the Bioventing Test Plot

3. Results from Analytical Testing of Soil-Gas Samples

Results of initial soil-gas analyses are shown in Table 9. Results of soil-gas analyses generally agree with soil analyses, showing heavier contamination closer to the old pipeline and at deeper depths. The exception is shown at monitoring point MPB, where significant contamination is found at a shallower depth. This is believed to be due to a surface spill. These results cannot be used as a direct indication of contaminant removal due to various physical/chemical processes. Thus, any future decrease in soil hydrocarbon concentration must be confirmed with soil sampling.

Table 9. Baseline BTEX and TPH Concentrations in Soil Gas Samples at the POL Yard: May 1996

Parameter	Concentration (ppmv)			
	MPA-6 m	MPB-2 m	MPC-6 m	MPD-6 m
TPH as jet fuel	4,600	8,000	220	0.40
Benzene	7.5	25	0.98	<0.002
Toluene	7.0	16	1.1	<0.002
Ethylbenzene	13	11	3.9	<0.002
Xylenes	32[1]	25	14	<0.002

[1] Reported value may be biased due to apparent matrix interferences.

In practice, at equilibrium the concentration of most petroleum hydrocarbon compounds of interest in the aqueous or gaseous phase is driven by the immiscible phase, if present, and the sorbed phase, if the immiscible phase is not present. If no immiscible phase is present, and all sorption sites on the solid soil matrix are not occupied, the vapor- or aqueous-phase concentration is a function of the sorbed concentration. This relationship typically follows a Langmuir-type curve. If the soil concentration is in excess of the sorption capacity of the soil, the aqueous-phase and gaseous-phase concentrations are Raoult's law-driven and are independent of the hydrocarbon concentration in the soil. This is an important concept in attempting to interpret soil-gas or groundwater data. For example, in a sandy site at which free product has been detected, the highest soil hydrocarbon concentrations may exceed 25,000 mg/kg. Yet 99% remediation to 250 mg/kg may not affect the equilibrium soil-gas or groundwater hydrocarbon concentrations.

4. Results from Monthly Soil-Gas Sampling

Relatively low concentrations of oxygen were found in soil-gas monitoring points sampled before initiation of air injection on August 22, 1991, with oxygen concentrations ranging from 0% to 18%, although most oxygen levels were less than 10% (Figure 13). Carbon dioxide and total hydrocarbon concentrations were correspondingly high, with many sampling points containing greater

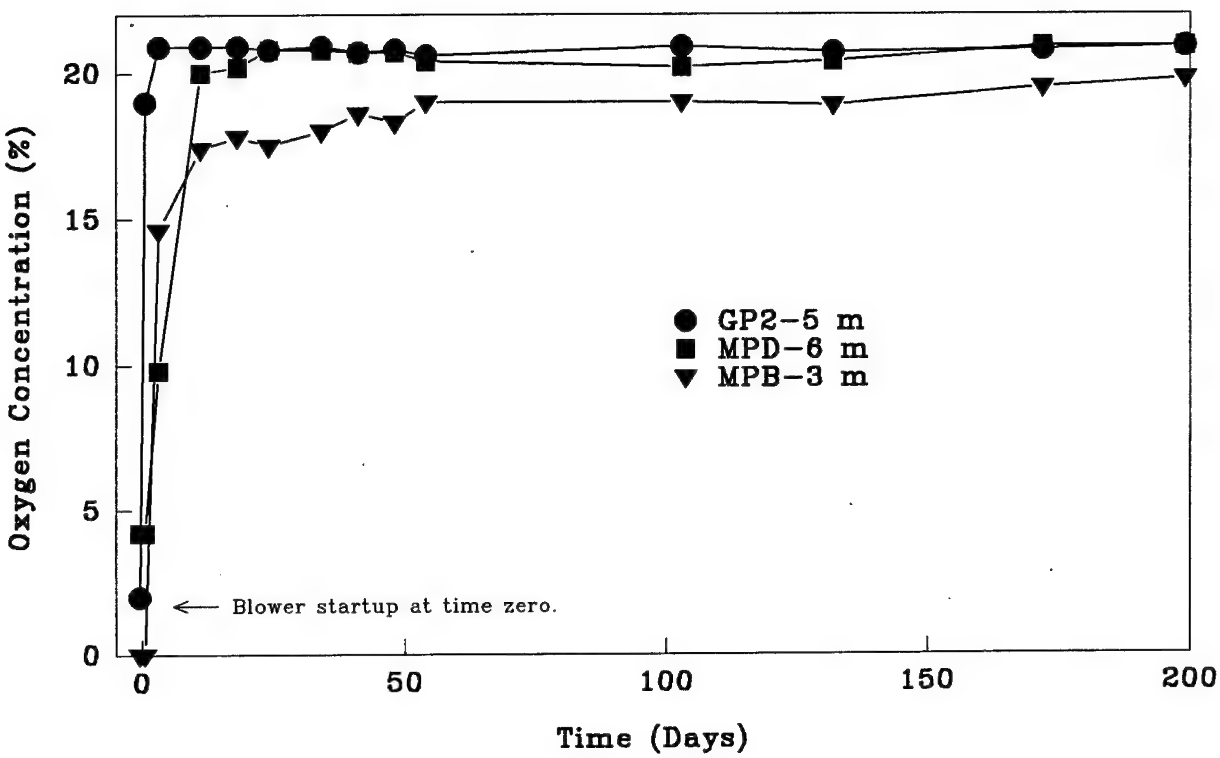

Figure 13. Average Oxygen Concentration Versus Time at Select Monitoring Points

than 10% carbon dioxide and greater than 5,000 ppm total hydrocarbon. Once air injection was initiated, oxygen concentrations increased with a corresponding drop in hydrocarbon concentration in most soil-gas monitoring points.

5. In Situ Respiration Test Results

Oxygen utilization rates measured in the bioventing test plot during August and November 1996 and August 1998 are shown in Tables 10, 11, and 12, respectively. During the August 1996 in situ respiration test, rates were highest at depths of 3 m and less in the vicinity of monitoring points MPA and MPB. The lowest rates were found in the area of monitoring point MPD. These results correlate with soil and soil-gas analyses, which demonstrated the highest contamination in the region of monitoring points MPA and MPB, with little contamination in the region of monitoring point MPD. Higher contamination levels will result in higher in situ respiration rates. Soil sample results also showed significant contamination at a depth of 7 to 8 m bgs; however, these soils are saturated, preventing the use of in situ respiration testing. Figure 14 illustrates the oxygen utilization curve at monitoring point MPB-2 m during August 1996.

In situ respiration rates during November 1996 (Table 11) were considerably lower than those measured during August 1996 (Table 10). Soil temperatures during November had dropped considerably, from approximately 20°C during August at the shallow depths, down to 8 to 12°C during November. This will have a significant impact on in situ respiration rates. Figure 15 illustrates the oxygen utilization curve at monitoring point MPB-2 m during the November 1996 testing.

In situ respiration rates during August 1998 (Table 12) were similar to those measured in November 1996, although soil temperatures were considerably higher during the August event. Soil temperatures were approximately 17 to 20°C at shallow depths in August 1998, which is comparable to temperatures during the August 1996 testing event. The in situ respiration rates were highest at depths of 2 to 3 m in the vicinity of monitoring points MPA and MPB, which is consistent with the results of previous tests. Overall, the 1998 rates were considerably lower than the 1996 respiration rates. These results are indicative of lower microbial activity due to lower contaminant levels.

6. Results from Soil Sampling

a. Initial

In general, the highest initial contaminant levels were found at the deeper depths close to the location of the former pipeline. TPH and BTEX also were high at shallower depths near the southeastern portion of the test plot. POL Yard personnel reported that there was a large surface spill in this area that probably resulted in the contamination in the test plot at these depths. Average BTEX and TPH concentrations by depth are shown in Figures 16 and 17. TPH concentrations ranged from below detection limits up to approximately 2,000 mg/kg, while BTEX concentrations ranged from below detection limits up to approximately 20 mg/kg. The total mass of TPH in soil is estimated to be 1,920 kg. This number is based on average TPH concentrations from the initial soil sampling event conducted prior to the initiation of bioventing. A cross section showing site geology and contaminant concentration by depth is shown in Figure 18.

Table 10. In Situ Respiration Results at the POL Yard: August 1996

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPA	1	3.7	2.5
	2	2.3	1.5
	3	1.6	1.1
	4	1.1	0.74
	5	0.59	0.40
	6	0.29	0.20
	7	NS	NS
	8	NS	NS
MPB	1	2.7	1.8
	2	3.2	2.2
	3	2.5	1.7
	4	0.98	0.67
	5	0.61	0.42
	6	0.38	0.26
	7	NS	NS
	8	NS	NS
MPC	1	0.19	0.13
	2	0.55	0.38
	3	0.58	0.39
	4	0.30	0.21
	5	0.19	0.13
	6	0.082	0.056
	7	NS	NS
	8	NS	NS

Table 10. In Situ Respiration Results at the POL Yard: August 1996 (continued)

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPD	1	0.10	0.070
	2	0.081	0.055
	3	0	0
	4	0	0
	5	0	0
	6	0	0
	7	NS	NS
	8	NS	NS
Background	1	0.029	0.020
	2	0.030	0.021
	3	0.0090	0.0060
	4	0.051	0.034
	5	0.031	0.021
	6	0.081	0.055
	7	0.060	0.041
	8	NS	NS
GP1	1.8	0.59	0.40
	3.25	1.2	0.79
	4.8	0.46	0.32
	6.3	0.26	0.18

Table 10. In Situ Respiration Results at the POL Yard: August 1996 (continued)

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
GP2	2.5	0.26	0.18
	3.25	0.29	0.19
	4.95	0.13	0.090
	6.55	NS	NS
GP3	2.0	0.16	0.11
	3.5	0.011	0.0070
	4.95	0.040	0.028
	6.5	NS	NS
GP4	2.0	0.11	0.075
	3.5	0	0
	5.0	0	0
	6.5	NS	NS
GP5	1.85	0.19	0.13
	3.4	0	0
	4.75	0	0
	6.1	0	0
GP8	2.0	0.39	0.27
	3.5	0.12	0.082
	5.0	0.039	0.027
	6.5	0	0

NS = Not sampled. Samples could not be collected because screened interval was below water table.

Table 11. In Situ Respiration Results at the POL Yard: November 1996

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPA	1	0.66	0.45
	2	0.70	0.48
	3	0.52	0.35
	4	0.40	0.27
	5	0.41	0.28
	6	0.15	0.10
	7	NS	NS
	8	NS	NS
MPB	1	0.47	0.32
	2	0.62	0.42
	3	0.74	0.50
	4	0.47	0.32
	5	0.43	0.29
	6	0.36	0.25
	7	NS	NS
	8	NS	NS
MPC	1	0.058	0.039
	2	0.19	0.13
	3	0.27	0.19
	4	0.25	0.17
	5	0.11	0.073
	6	0.068	0.046
	7	NS	NS
	8	NS	NS

Table 11. In Situ Respiration Results at the POL Yard: November 1996 (continued)

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPD	1	0.068	0.046
	2	0.087	0.059
	3	0.058	0.039
	4	0.019	0.013
	5	0.058	0.039
	6	0.058	0.039
	7	NS	NS
	8	NS	NS
Background	1	0	0
	2	0	0
	3	0	0
	4	0	0
	5	0	0
	6	0	0
	7	0	0
	8	NS	NS
GP1	1.8	0.14	0.10
	3.25	0.20	0.13
	4.8	0.068	0.047
	6.3	0	0

Table 11. In Situ Respiration Results at the POL Yard: November 1996 (continued)

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
GP2	2.5	0.037	0.025
	3.25	0.067	0.046
	4.95	0.11	0.073
	6.55	0.018	0.012
GP3	2.0	0.030	0.020
	3.5	0.019	0.013
	4.95	0	0
	6.5	NS	NS
GP4	2.0	0.087	0.059
	3.5	0.019	0.013
	5.0	0.019	0.013
	6.5	0.019	0.013
GP5	1.85	0	0
	3.4	0.029	0.020
	4.75	0	0
	6.1	0	0
GP8	2.0	0.029	0.020
	3.5	0.039	0.027
	5.0	0	0
	6.5	0	0

NS = Not sampled. Samples could not be collected because screened interval was below water table.

Table 12. In Situ Respiration Results at the POL Yard: August 1998

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPA	1	0	0
	2	0.83	0.56
	3	0.63	0.43
	4	0.39	0.27
	5	0.25	0.17
	6	0.21	0.14
	7	NS	NS
	8	NS	NS
MPB	1	0.48	0.33
	2	1.69	1.1
	3	1.34	0.91
	4	0.29	0.20
	5	0.080	0.054
	6	0.080	0.054
	7	NS	NS
	8	NS	NS
MPC	1	1.0	0.70
	2	0	0
	3	0	0
	4	0	0
	5	0.15	0.10
	6	0.13	0.088
	7	NS	NS
	8	NS	NS

Table 12. In Situ Respiration Results at the POL Yard: August 1998 (continued)

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
MPD	1	0.070	0.048
	2	0.17	0.12
	3	0.080	0.054
	4	0.13	0.088
	5	0.21	0.14
	6	0.15	0.10
	7	NS	NS
	8	NS	NS
Background	1	0.050	0.034
	2	0	0
	3	0	0
	4	0.11	0.075
	5	0.080	0.054
	6	0.050	0.034
	7	0.017	0.012
	8	NS	NS
GP1	1.8	0	0
	3.25	0.66	0.45
	4.8	0.070	0.048
	6.3	0	0

Table 12. In Situ Respiration Results at the POL Yard: August 1998 (continued)

Monitoring Point	Depth (m)	Oxygen Utilization Rate (%/day)	Biodegradation Rate (mg/kg-day)
GP2	2.5	0.11	0.075
	3.25	0	0
	4.95	0.16	0.11
	6.55	0.077	0.052
GP3	2.0	0	0
	3.5	0.019	0.013
	4.95	0	0
	6.5	NS	NS
GP4	2.0	0	0
	3.5	0	0
	5.0	0	0
	6.5	0	0
GP5	1.85	0	0
	3.4	0	0
	4.75	0	0
	6.1	0	0
GP8	2.0	0	0
	3.5	0	0
	5.0	0	0
	6.5	0.10	0.068

NS = Not sampled. Samples could not be collected because screened interval was below water table.

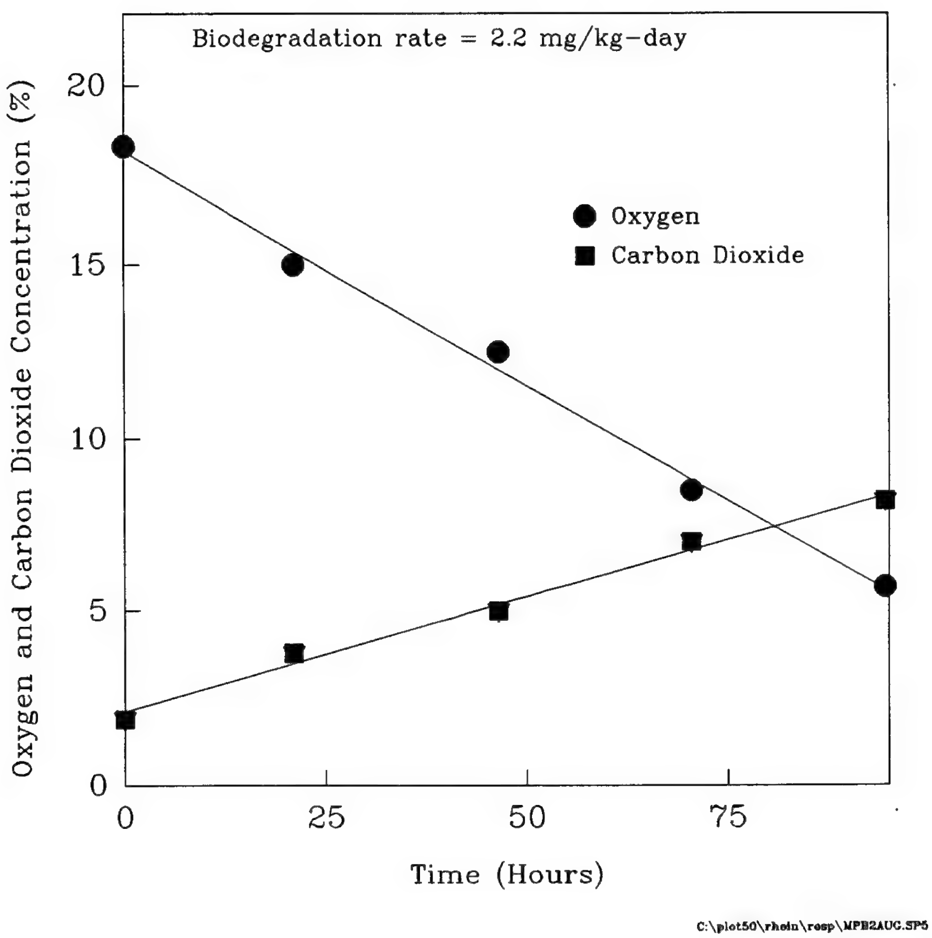

Figure 14. In Situ Respiration Test Results at Monitoring Point MPB-2 m: August 1996

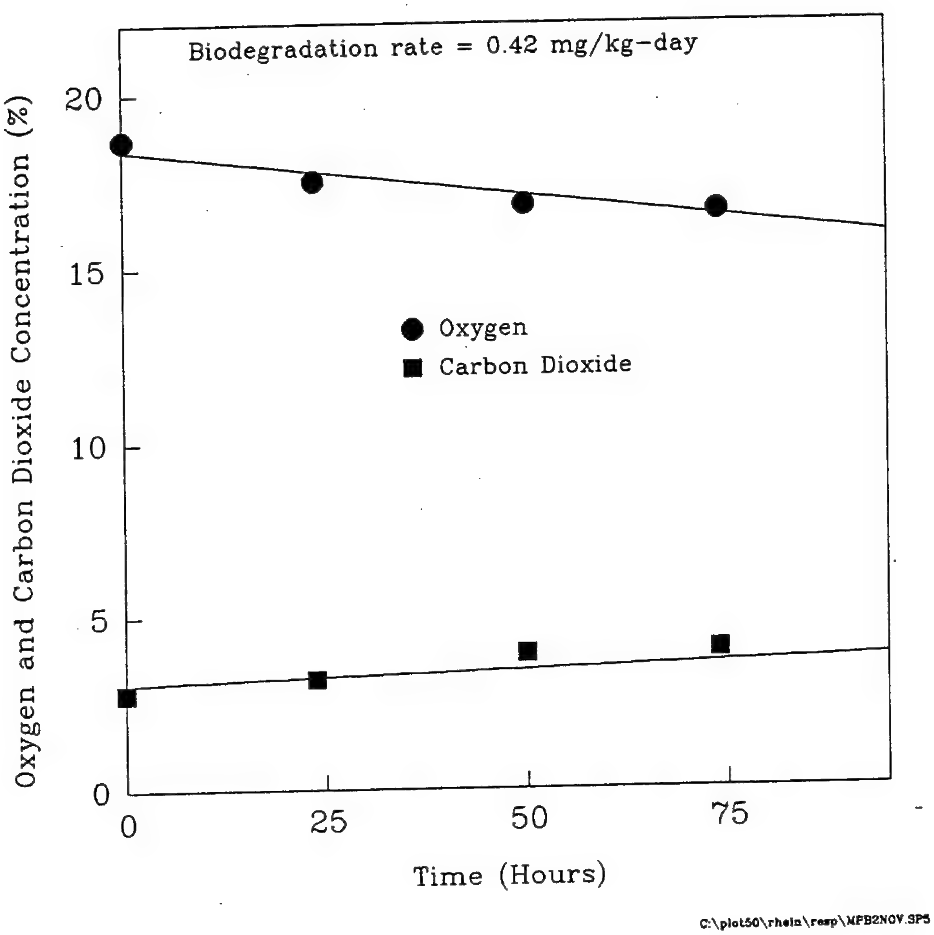

Figure 15. In Situ Respiration Test Results at Monitoring Point MPB-2 m: November 1996

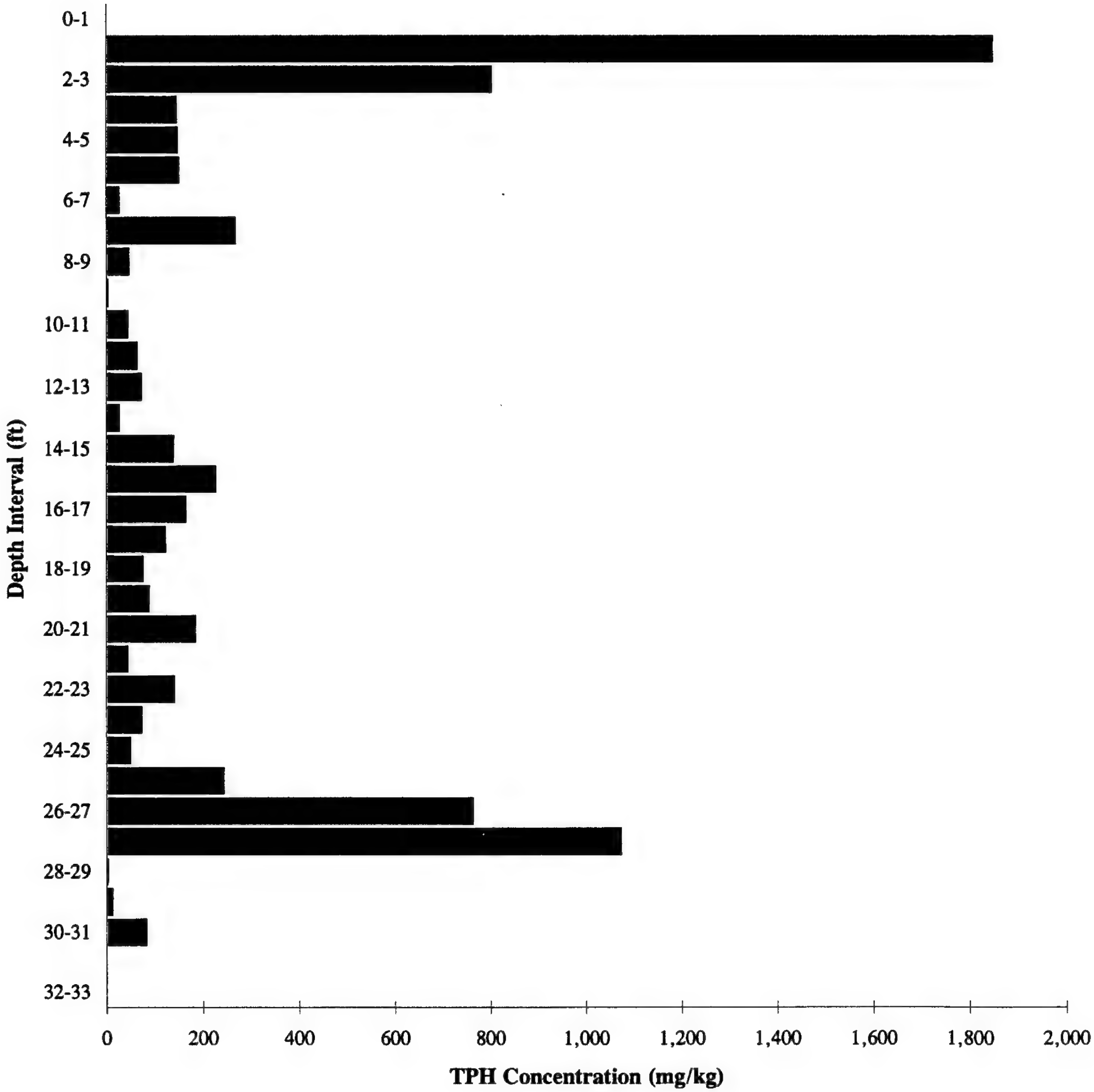

Figure 16. Initial Average TPH Soil Concentrations by Depth

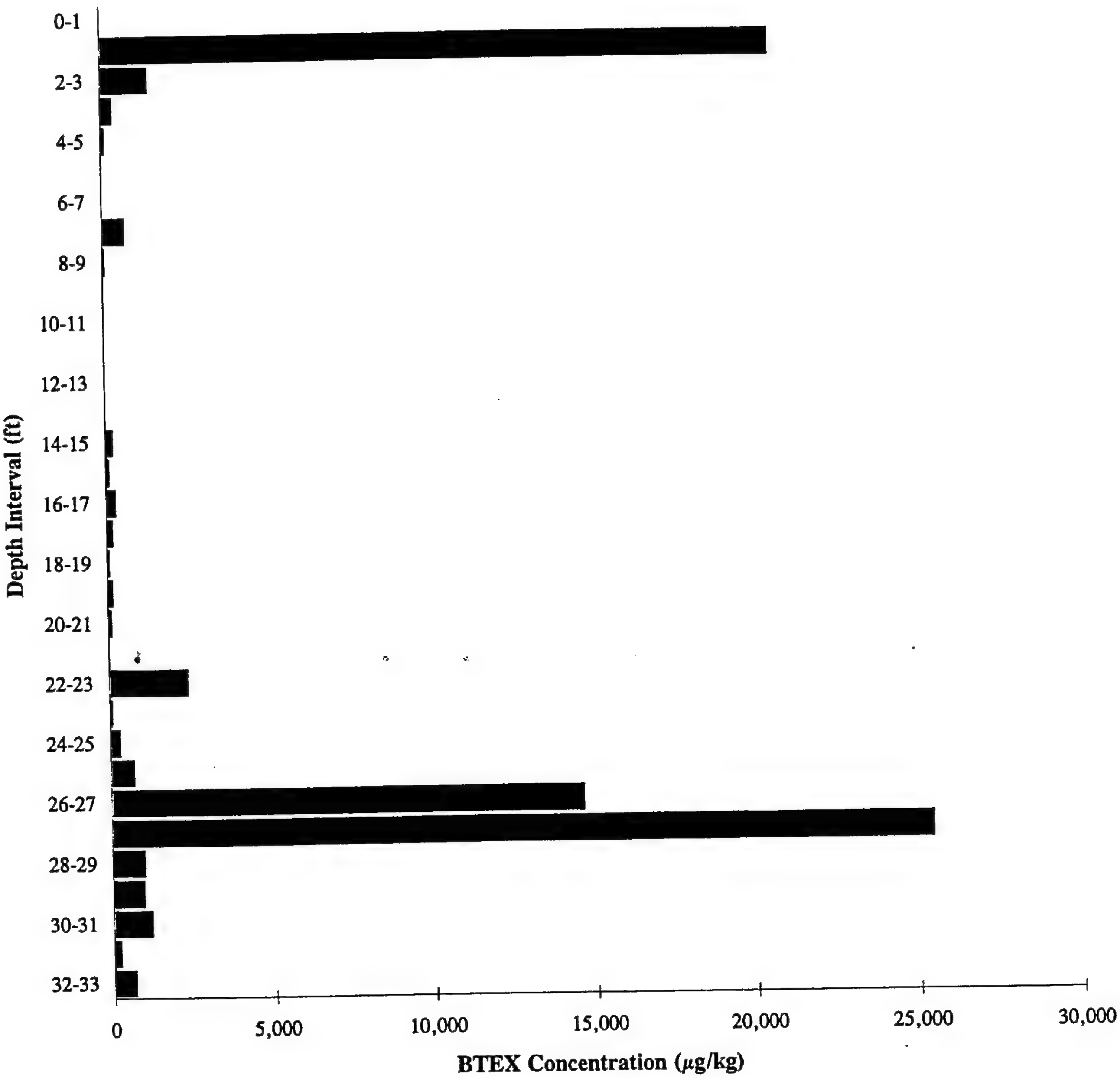

Figure 17. Initial Average BTEX Soil Concentrations by Depth

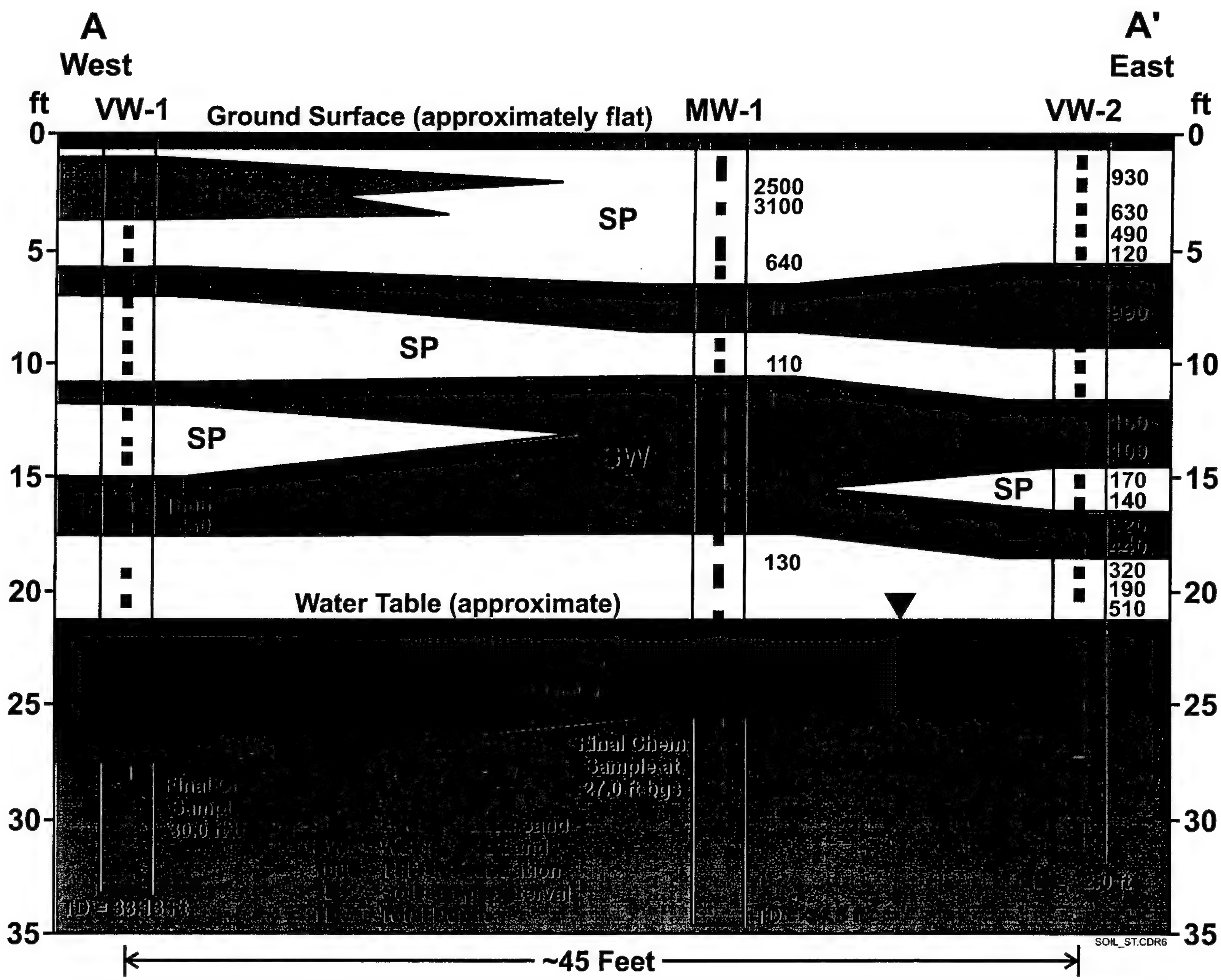

Figure 18. Cross Section Showing Site Geology and Contaminant Concentration by Depth

Seven soil samples, each from a different depth, were analyzed to determine soil characteristics (Tables 13 and 14). All values of the inorganic parameters fall within ranges observed at successful bioventing sites (Leeson and Hinchee, 1996).

b. Final

Final soil sampling was performed with a Geoprobe® unit at locations adjacent to respective vent wells and monitoring points that were sampled during the initial installation. Continuous sampling was not performed as was done during the initial sampling round, rather depths showing the highest contaminant concentrations in the initial round were resampled for comparison purposes. Figures 19 through 28 compare TPH and BTEX concentrations from initial and final soil sampling according to depth for each of the four vent wells and one monitoring well. Results indicate a significant reduction in contaminant concentration in soil with the exception of several depths below the water table level. This type of behavior is expected, since bioventing would not effectively treat soil contamination located in the saturated zone unless the water table was actively drawn down to expose these soils. The water table was at approximately 22 ft bgs at the time of final soil sampling.

In general, the highest final contaminant levels were found in VW-1 and VW-3 at deeper depths that are saturated during parts or all of the year. TPH and BTEX also remained slightly elevated at several shallower depths, possibly associated with the surface spill indicated above. However, concentrations at these locations were significantly lower in the final sampling event as compared to the initial sampling event. Average BTEX and TPH concentrations by depth across the entire site for the final sampling event are shown in Figures 29 and 30. Note that these figures represent only depths that were sampled during the final sampling event due to elevated concentrations in the initial event. They do not represent a continuous soil profile of wells across the entire site.

E. SUMMARY AND CONCLUSIONS

Based on the results from the study period, the following can be concluded:

1. The bioventing process is stimulating biodegradation. The average in situ respiration rate at a depth of 0 to 3 m was initially 1.8 mg/kg-day during the warm months and 0.42 mg/kg-day during colder months. At a depth of 3 to 6 m, the average in situ respiration rate during the warm months was initially 0.36 mg/kg-day and 0.18 mg/kg-day during colder months. During the final respiration test conducted in a warm month, the average in situ respiration rate at a depth of 0 to 3 m was 0.56 mg/kg-day and 0.15 mg/kg-day at a depth of 3 to 6 m. Since the initiation of bioventing, these rates correspond to an estimated 2,800 kg total hydrocarbon removal. Cumulative hydrocarbon removal at the two depth intervals is shown in Figure 31.

2. Surface emissions at the site appear to be minimal. Surface emissions measured during October 1996 and August 1998 allowed for comparison of emissions during injection and without injection. Surface emissions measured in October 1996 were significantly lower than those measured during initial testing in April 1996. In most samples, none of the BTEX components could be detected. Very little difference could be detected between samples collected during injection and without injection. In

Table 13. Results of Inorganic Soil Analyses at the POL Yard

Sample	Alkalinity (mg/kg)	Iron (mg/kg)	Moisture Content (%)	pH	TKN (mg/kg)	TP (mg/kg)	Total Sulfate (mg/kg)	Soluble Sulfate (mg/kg)	Sulfide (mg/kg)
RM1-VW4-1.5-1.66	70	8,300	6.4	7.37	490	26	NM	NM	NM
RM1-VW4-1.66-1.82	NM	NM	NM	NM	NM	NM	460	26	130
RM1-VW4-3.05-3.21	120	2,700	10	8.24	<100	43	NM	NM	NM
RM1-VW4-3.21-3.38	NM	NM	NM	NM	NM	NM	150	28	20
RM1-VW4-4.87-5.04	210	2,500	5.7	8.22	630	94	NM	NM	NM
RM1-VW4-5.04-5.20	NM	NM	NM	NM	NM	NM	180	11	80
RM1-VW4-5.79-5.96	90	250	4.5	7.94	<100	25	NM	NM	NM
RM1-VW4-5.96-6.12	NM	NM	NM	NM	NM	NM	180	17	20
RM1-VW4-6.44-6.60	400	2,100	5.4	9.09	160	83	NM	NM	NM
RM1-VW4-6.60-6.76	NM	NM	NM	NM	NM	NM	150	32	10
RM1-VW4-7.09-7.25	80	270	12.8	8.19	6,300	14	NM	NM	NM
RM1-VW4-7.25-7.41	NM	NM	NM	NM	NM	NM	150	40	60
RM1-VW4-8.06-8.22	70	900	12.7	8.57	<100	13	NM	NM	NM
RM1-VW4-9.02-9.18	NM	NM	NM	NM	NM	NM	30	50	10

NM = Not measured.

Table 14. Particle Size Classification of Soils from the POL Yard

Sample	Particle Size (%)		
	Gravel	Sand	Silt/Clay
RM1-1.82-2.15	37	62	<1.0
RM1-3.38-3.0	54	45	<1.0
RM1-5.20-5.52	46	53	<1.0
RM1-6.12-6.44	36	64	0
RM1-6.76-7.09	16	84	0
RM1-7.57-7.90	11	89	0
RM1-VW4-8.39-8.78	57	43	0
RM1-VW4-8.78-8.95	59	41	0
RM1-VW4-9.34-9.66	48	52	0

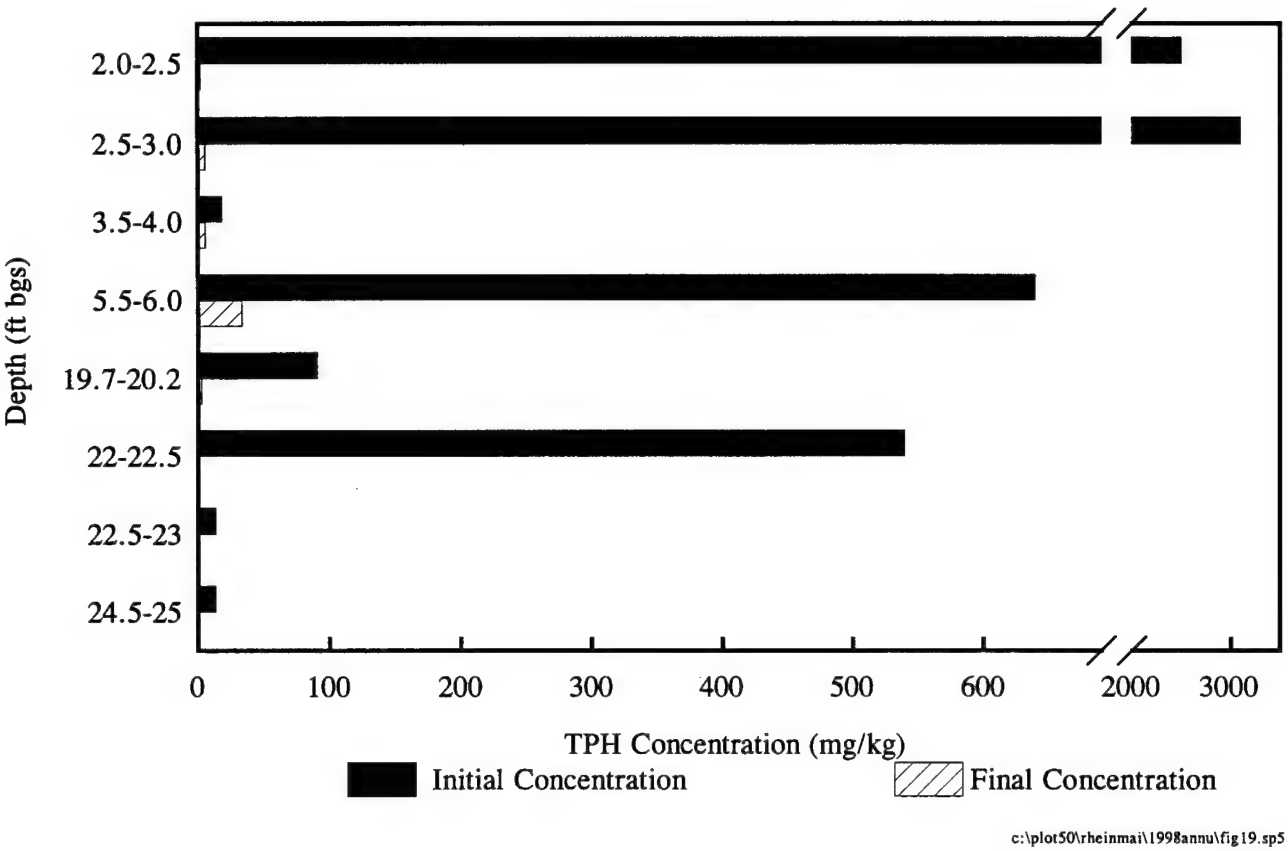

Figure 19. TPH Concentrations in Soil at MW1 Over Time

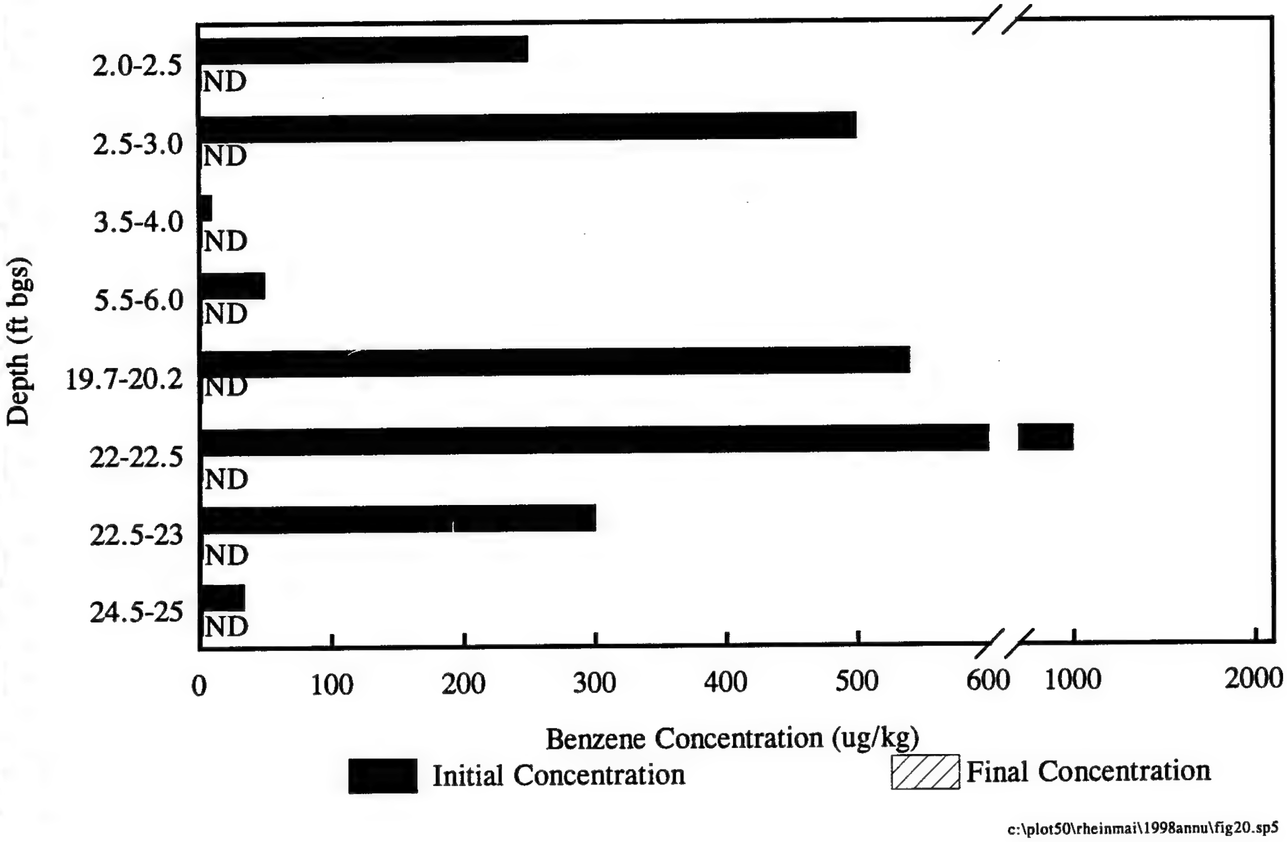

Figure 20. Benzene Concentrations in Soil at MW1 Over Time

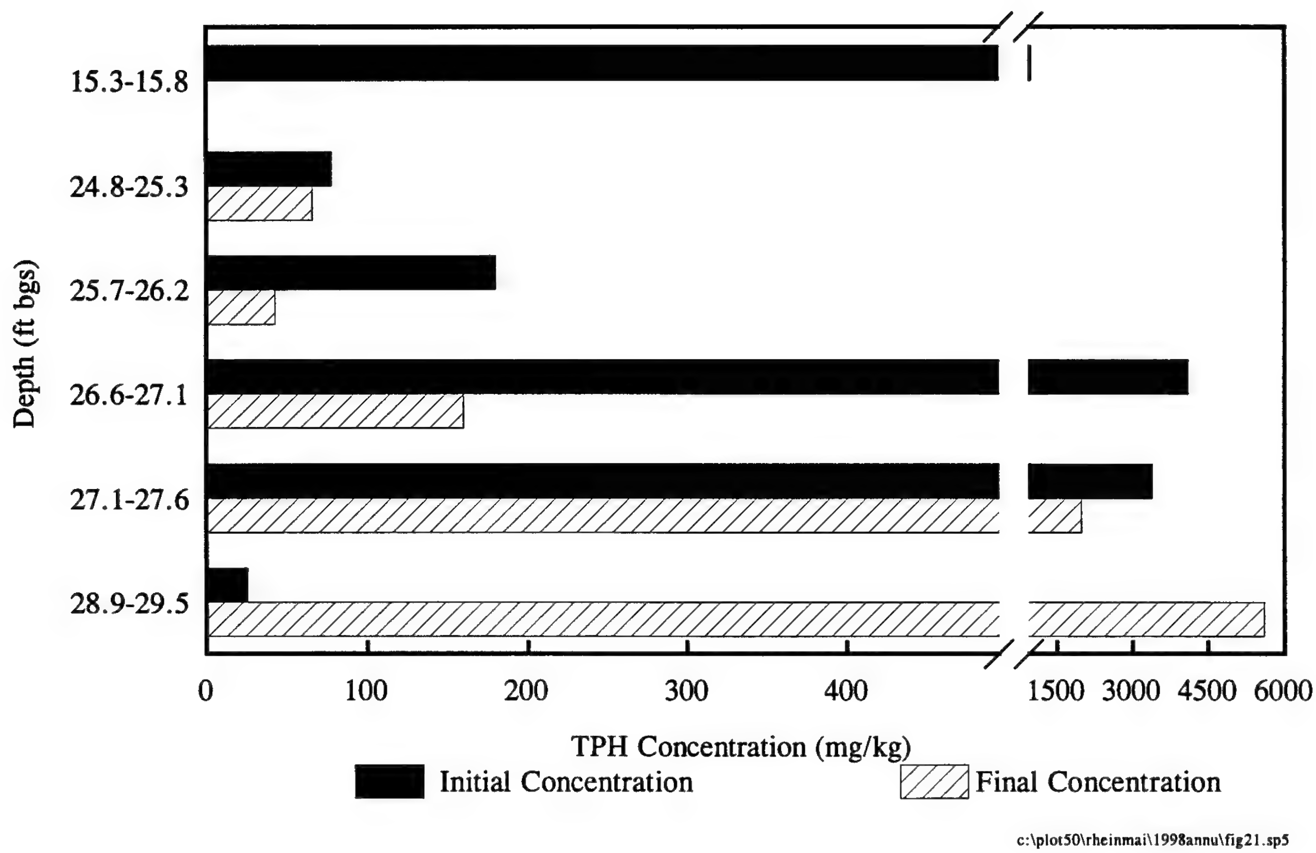

Figure 21. TPH Concentrations in Soil at VW1 Over Time

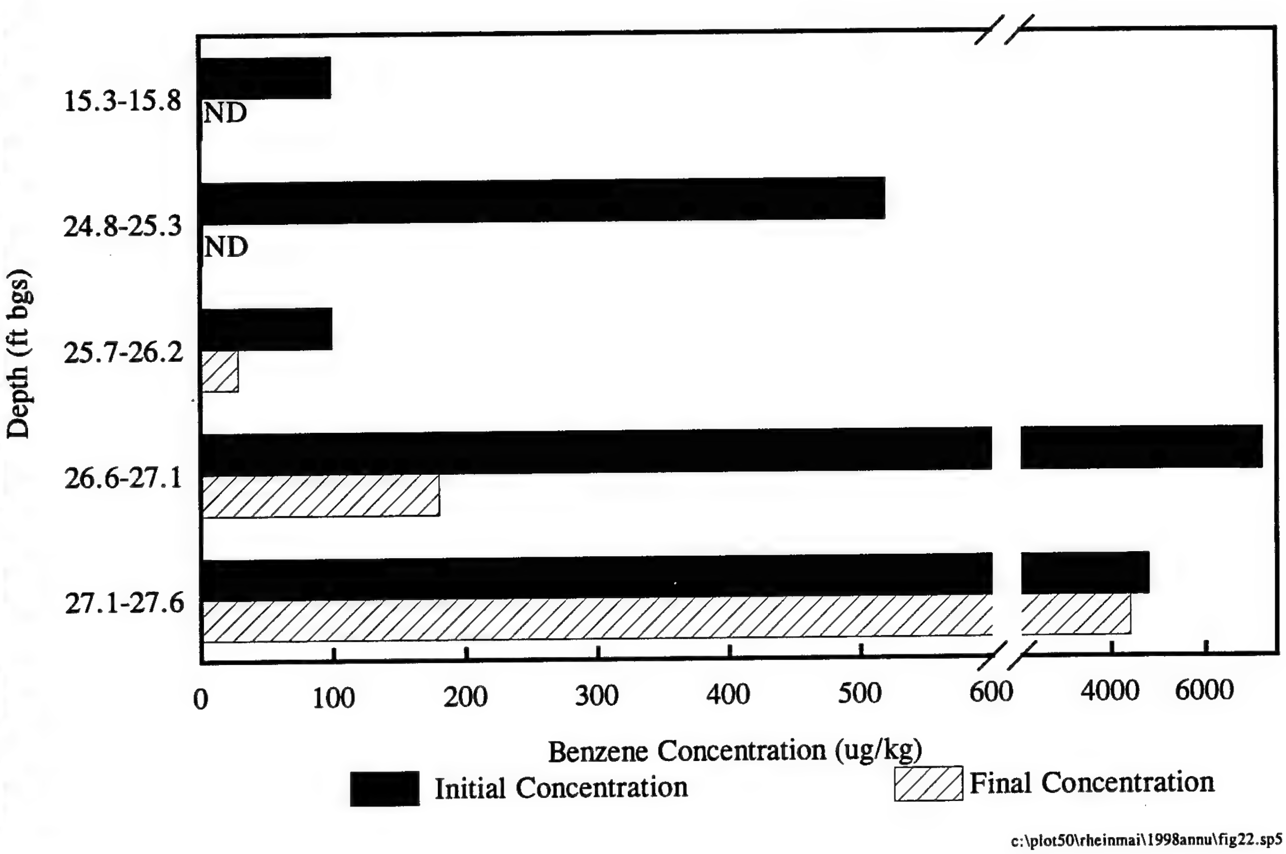

Figure 22. Benzene Concentrations in Soil at VW1 Over Time

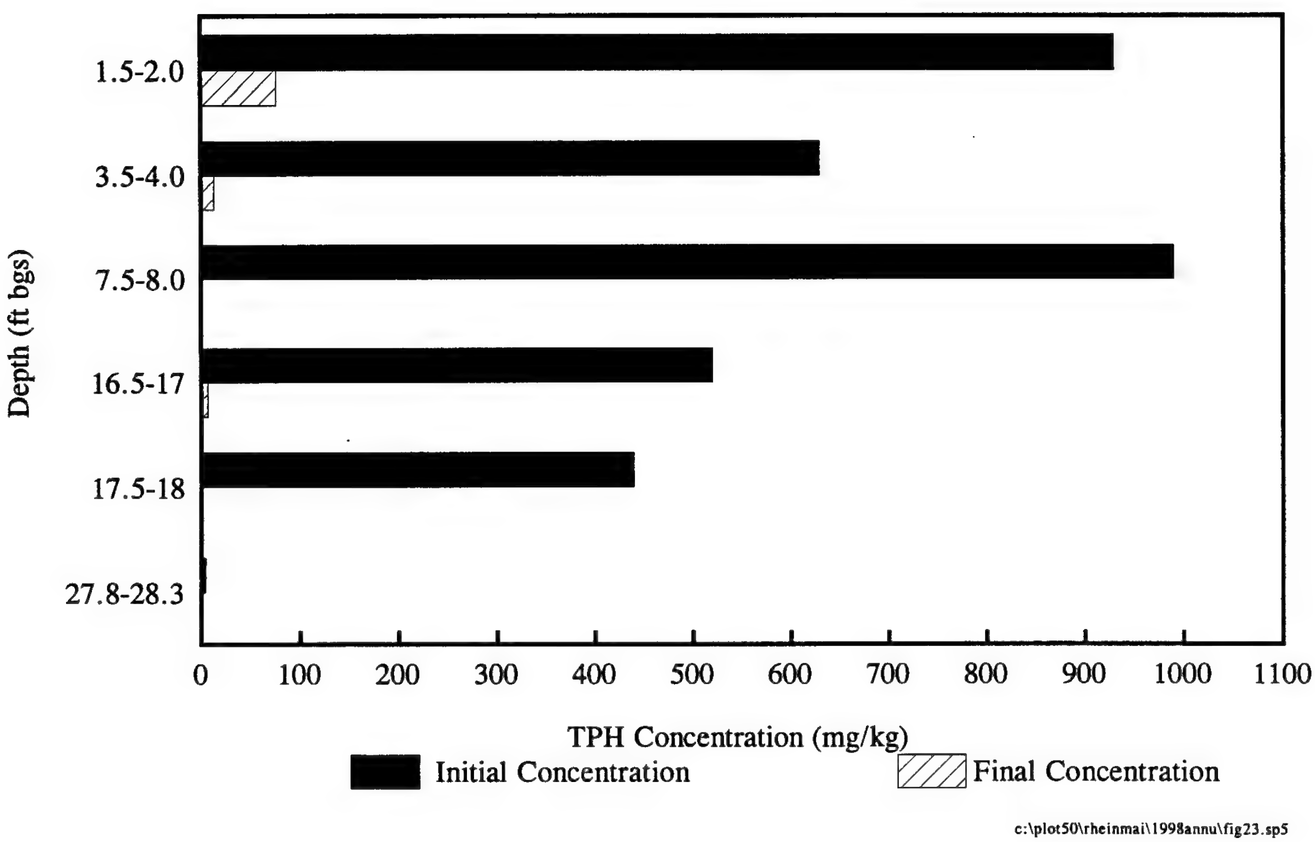

Figure 23. TPH Concentrations in Soil at VW2 Over Time

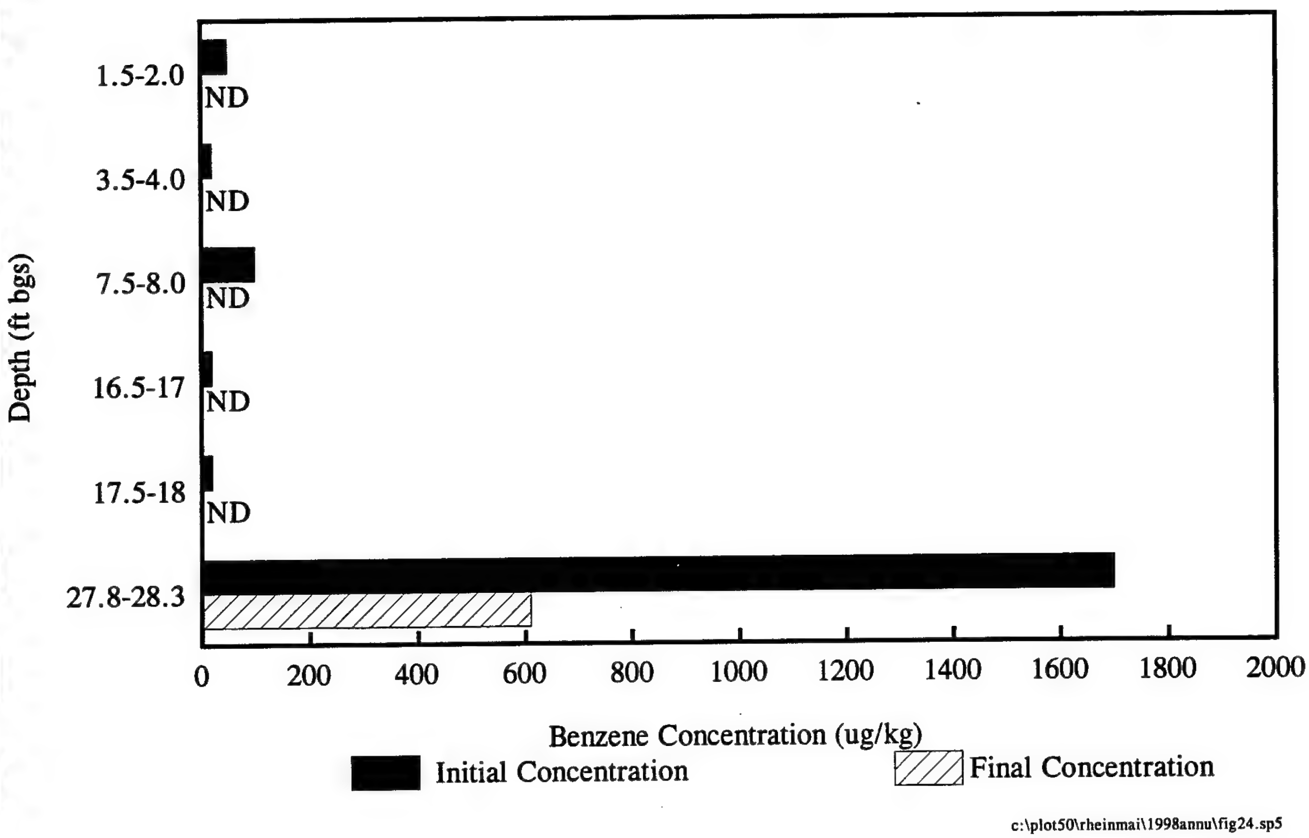

Figure 24. Benzene Concentrations in Soil at VW2 Over Time

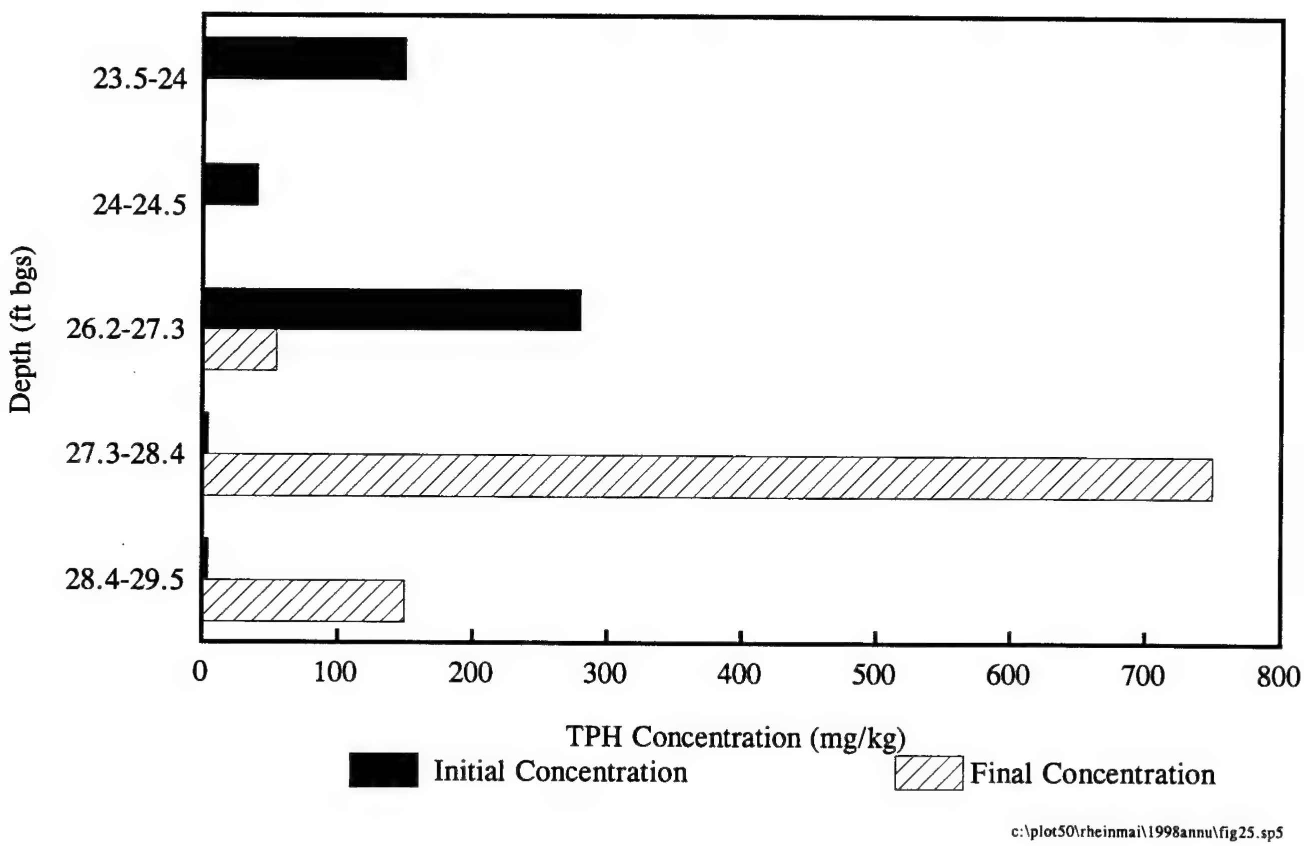

Figure 25. TPH Concentrations in Soil at VW3 Over Time

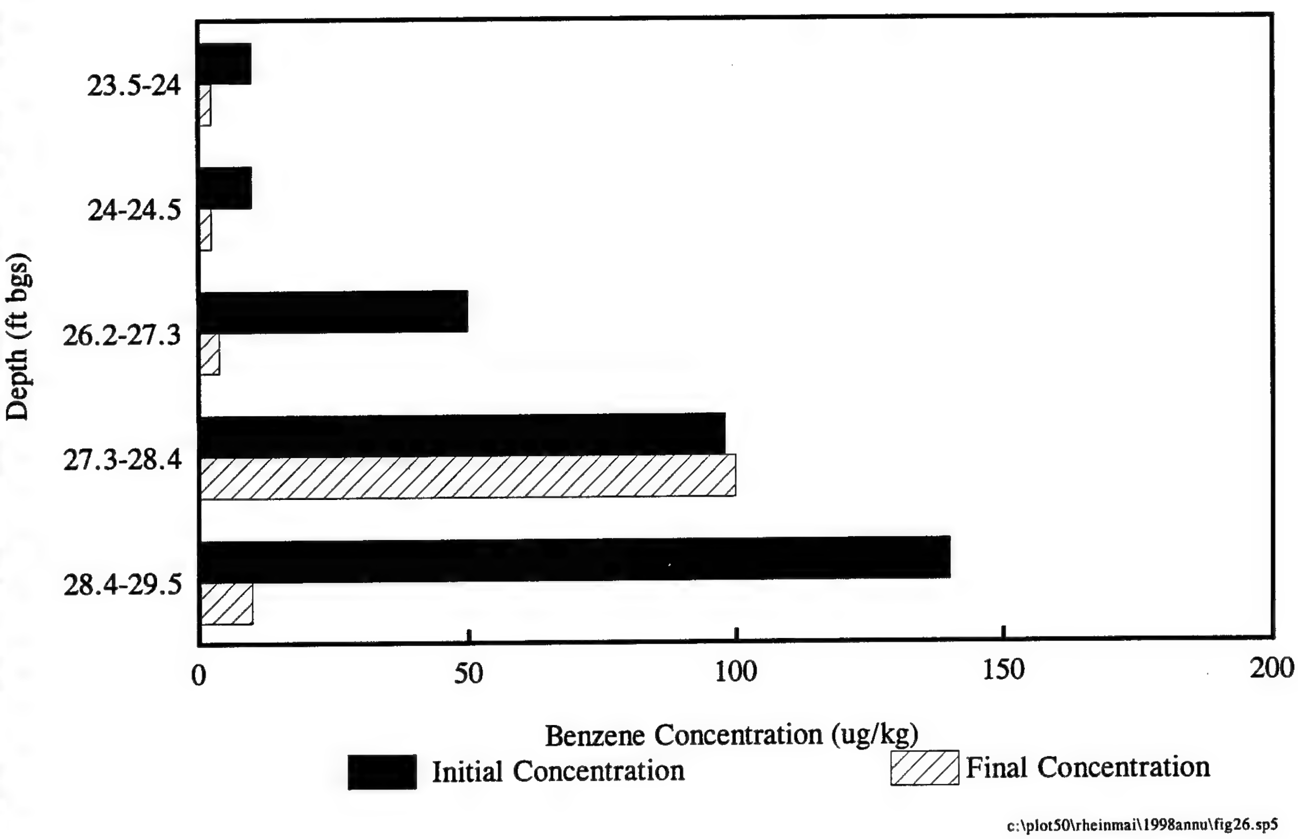

Figure 26. Benzene Concentrations in Soil at VW3 Over Time

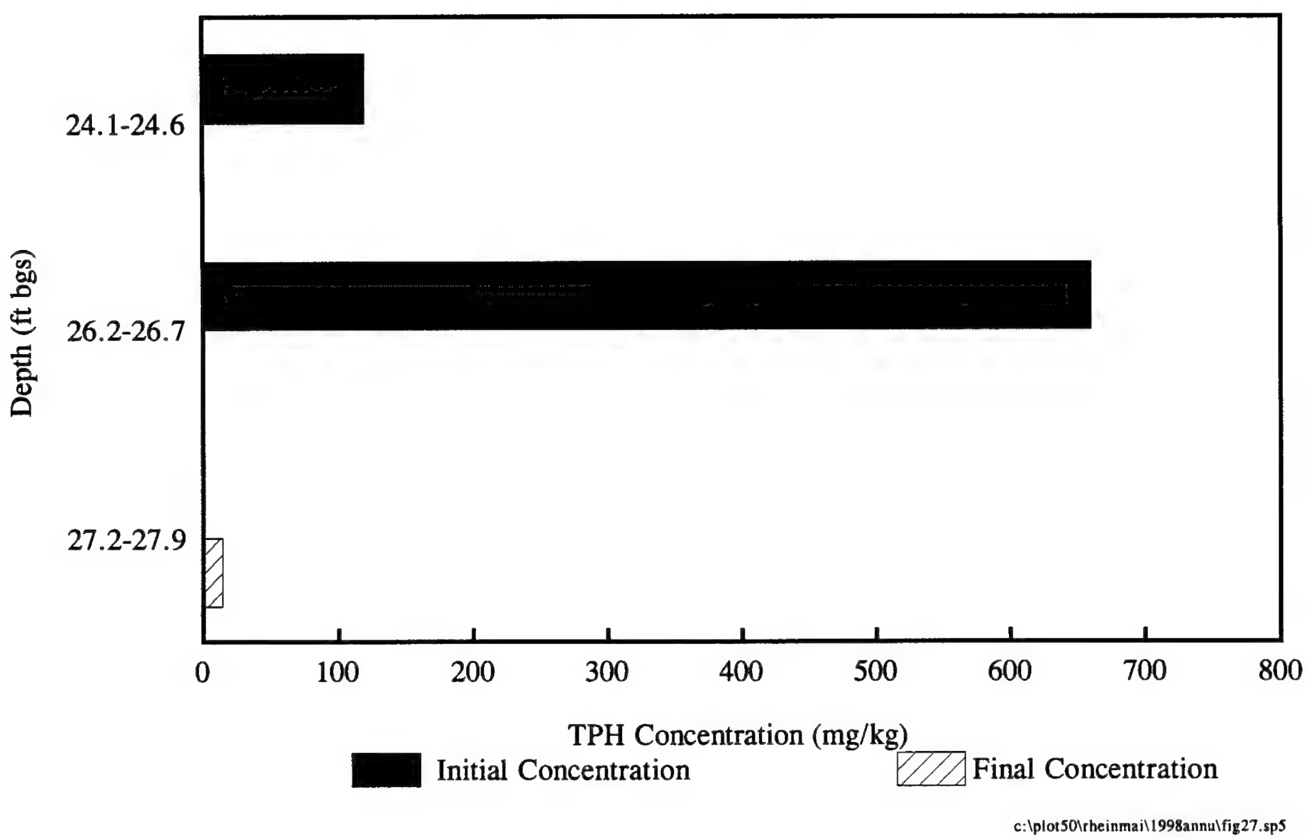

Figure 27. TPH Concentrations in Soil at VW4 Over Time

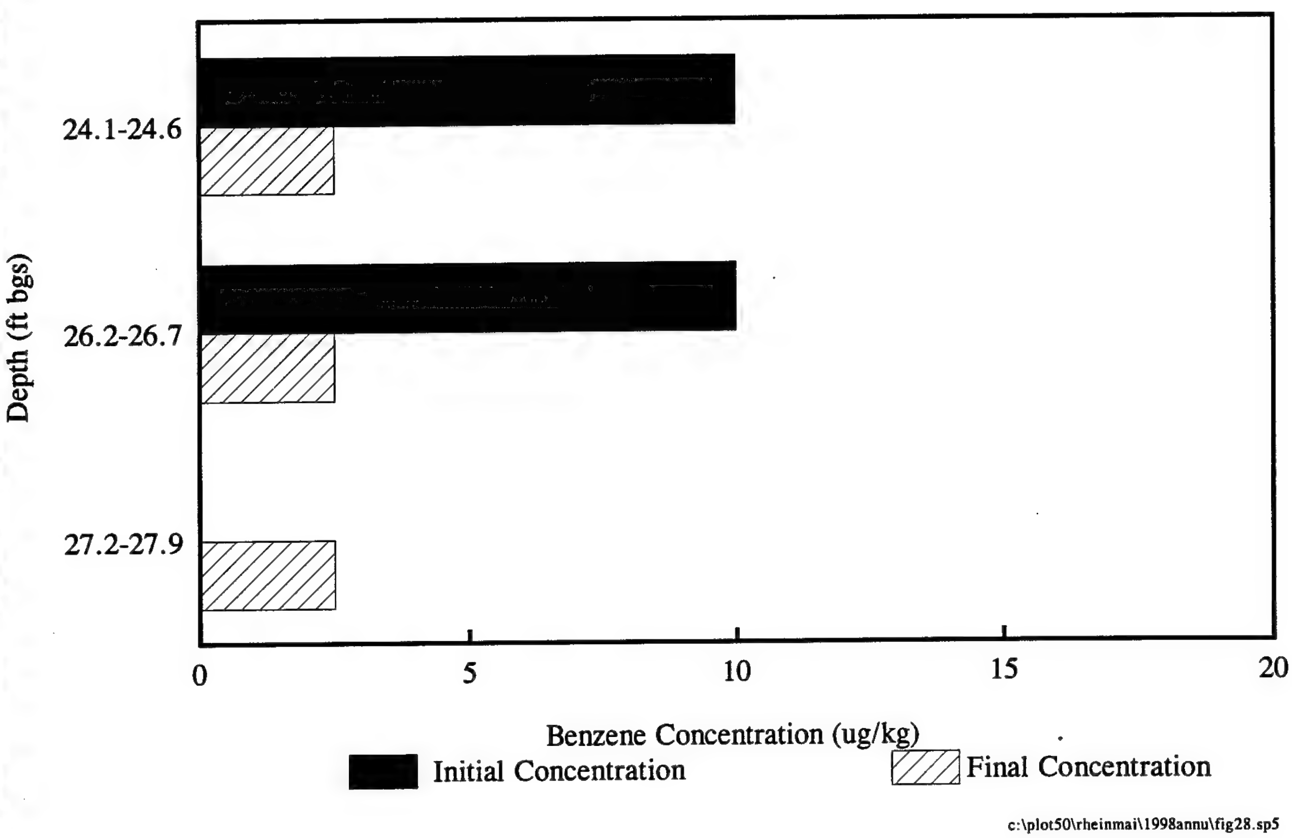

Figure 28. Benzene Concentrations in Soil at VW4 Over Time

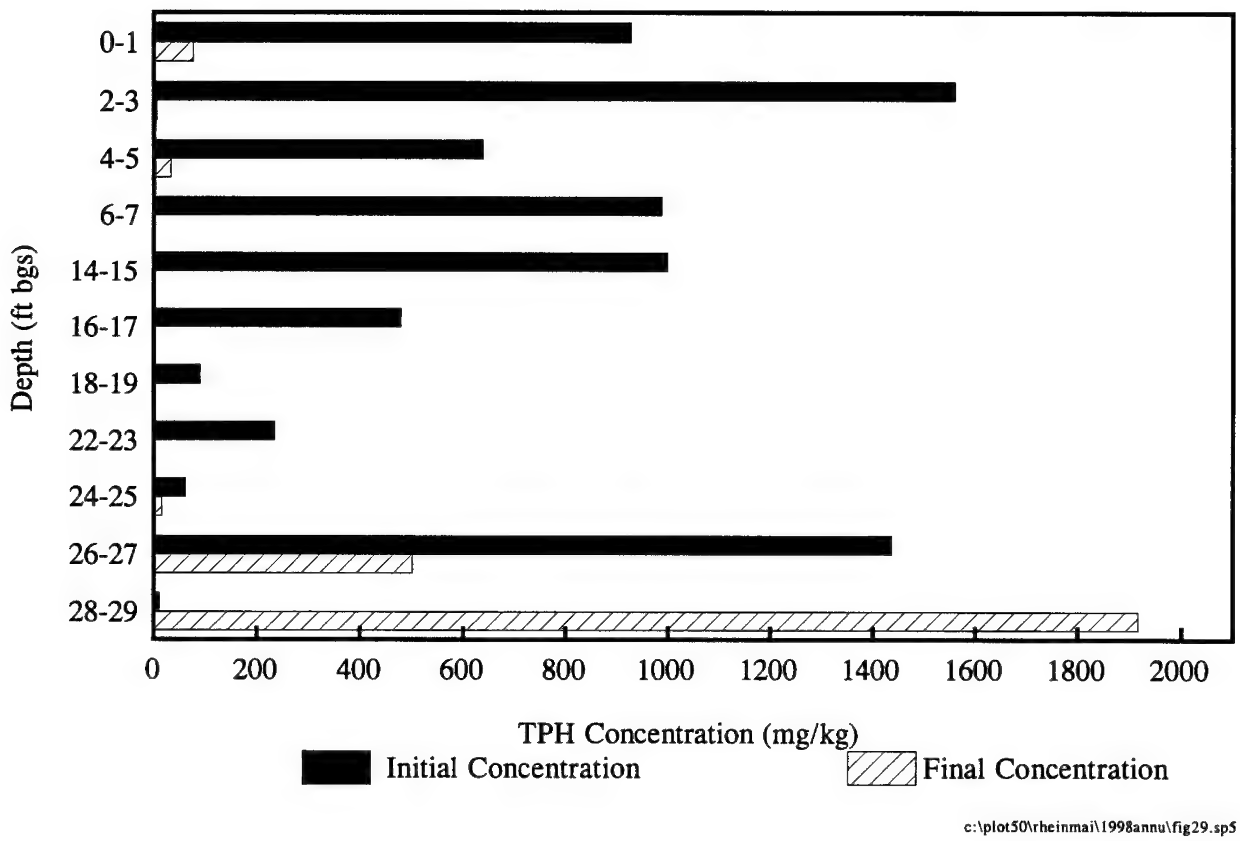

Figure 29. TPH Concentrations in Soil Across the Site Over Time

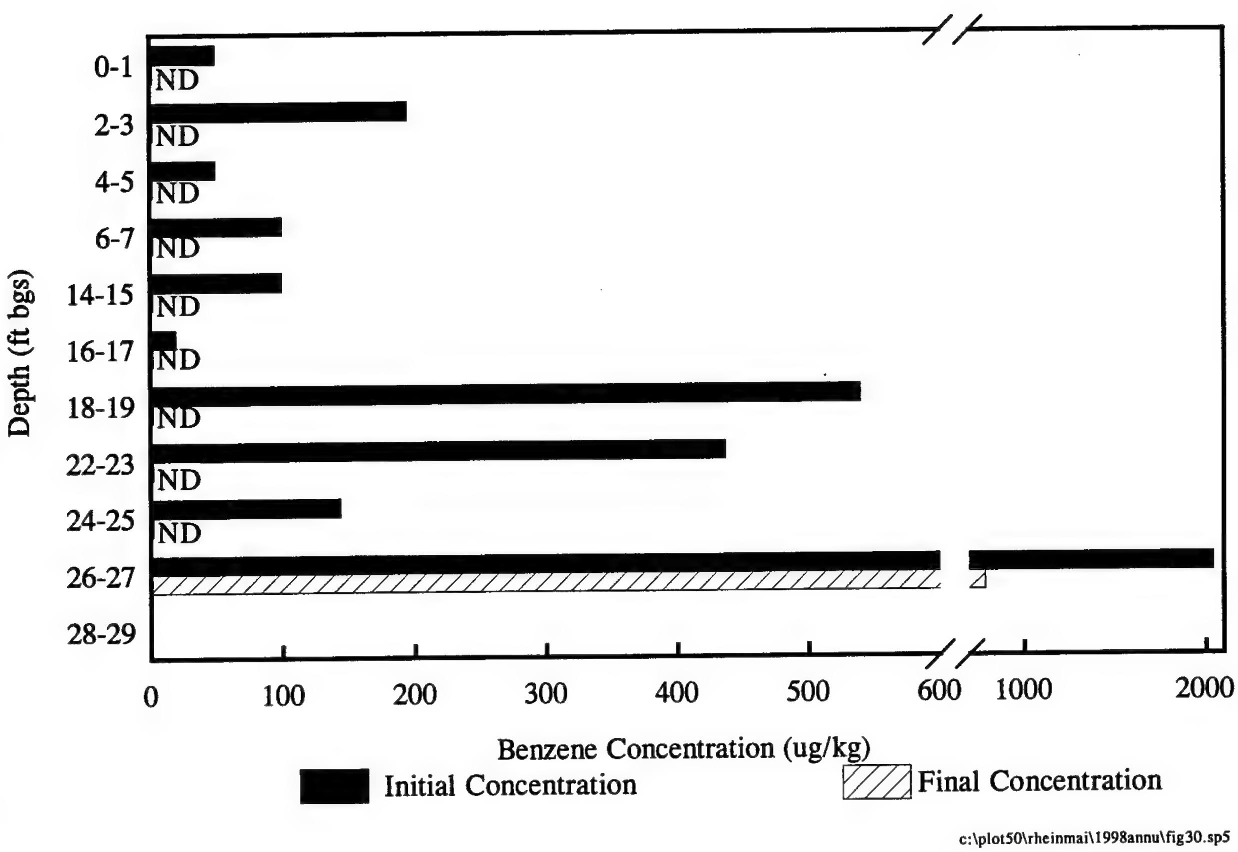

Figure 30. Benzene Concentrations in Soil Across the Site Over Time

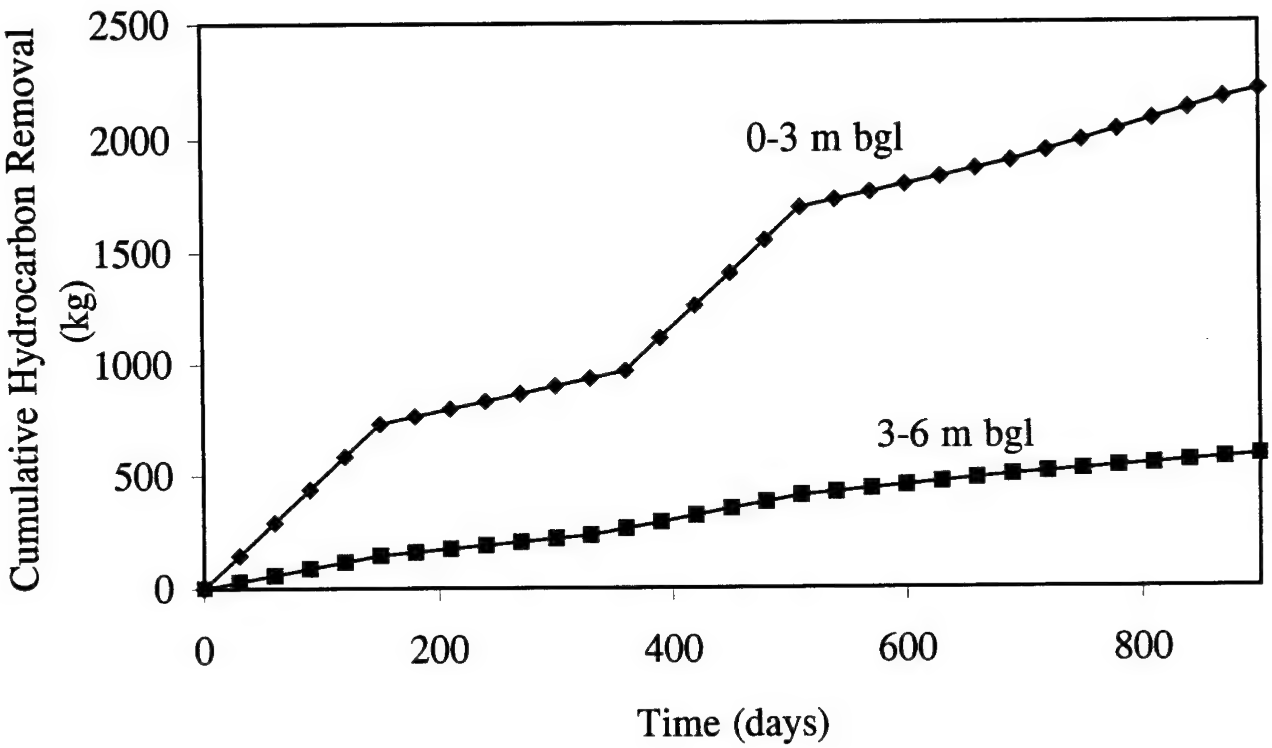

Figure 31. **Cumulative Hydrocarbon Removal in the Bioventing Test Plot at Two Depth Intervals**

the center of the test plot no benzene, ethylbenzene, or xylenes were detected in any samples either during or without injection and only trace amounts of toluene were detected during injection. In general, August 1998 surface emissions were significantly lower than those measured in April 1996 and somewhat greater than those measured in October 1996. The average benzene concentrations in the center of the test plot both with and without injection were below the initial benzene concentrations in surface emissions prior to treatment. These data again show that operation of the blower does not seem to affect surface emission concentrations of benzene in the center of the test plot. Benzene concentrations in perimeter samples collected both with and without blower operation were less than benzene concentrations in initial surface emission samples at the site. These results indicate that, at the locations sampled, the bioventing system is not creating a pronounced level of increased emissions over natural surface emissions at the site.

3. Pressure changes were monitored at all depths during the soil-gas permeability tests. In general, the radius of influence was greater at the deeper depths,with values ranging from 4.6 m (15 ft) at a depth of 2 m (6.6 ft) up to 11 m (37 ft) at a depth of 4 m (13 ft). Based on the data for the POL Yard and assuming that in general, most of the contamination is at the deeper depths, a radius of influence of 9 m (30 ft) may be sufficient for site coverage. This would necessitate a well spacing of 18 m (60 ft). At the 18-m spacing, approximately 12 wells would be sufficient to treat more than 4,000 m^2 ($\sim$1 acre) of site surface area.

4. Results of soil-gas analyses generally agree with soil analyses, showing heavier contamination closer to the old pipeline and at deeper depths. The exception is shown at monitoring point MPB, where significant contamination is found at a shallower depth. This is believed to be due to a surface spill.

5. During August 1996, in situ respiration rates were highest at depths of 3 m and less in the vicinity of monitoring points MPA and MPB. The lowest rates were found in the area of monitoring point MPD. These results correlate with soil and soil-gas analyses, which demonstrated the highest contamination in the region of monitoring points MPA and MPB, with little contamination in the region of monitoring point MPD. Higher contamination levels will result in higher in situ respiration rates. Soil sample results also showed significant contamination at a depth of 7 to 8 m bgs; however, these soils are saturated, preventing the use of in situ respiration testing. In situ respiration rates measured during November 1996 were significantly lower, most likely due to significantly lower soil temperatures. In situ respiration rates measured in August 1998 also were lower than August 1996 rates even at similar soil temperatures, indicating a reduction in contaminant concentrations in soil.

6. In general, the highest initial soil contaminant levels were found at the deeper depths close to the location of the former pipeline. TPH and BTEX also were high at shallower depths near the southeastern portion of the test plot. POL Yard personnel reported that there was a large surface spill in this area that probably resulted in the contamination in the test plot at these depths. TPH concentrations ranged from below detection limits up to approximately 2,000 mg/kg, while BTEX concentrations ranged from below detection limits up to approximately 20 mg/kg. The total mass of TPH

initially in soil is estimated to be 1,920 kg. This number is based on average TPH concentrations in soil by depth prior to the initiation of bioventing. All values of the inorganic parameters fall within ranges observed at successful bioventing sites. Results of final soil sampling indicate a significant reduction in contaminant concentration in soil with the exception of several depths below the water table level. In general, the highest final TPH and benzene concentrations were found in VW-1 and VW-3 at deeper depths that are saturated during parts or all of the year. TPH and BTEX also remained slightly elevated at several shallower depths, possibly associated with the surface spill indicated above. However, concentrations at these locations were significantly lower in the final sampling event as compared to the initial sampling event.

SECTION IV
NATURAL ATTENUATION DEMONSTRATION

A. SITE SELECTION AND EVALUATION

1. Site History and Data Review

Battelle selected an appropriate site for the natural attenuation demonstration by evaluating existing literature and information on the general hydrogeology and the nature and extent of groundwater contamination at Rhein-Main Air Base. Site selection criteria included locating a well-characterized, fuel-rich source and plume that was not co-mingled with contamination from other sources and that was not disturbed by pumping, remedial activities, or physical features that would impact the physical mobility or chemistry of the plume. The plume also needed to be contained in an aquifer that could be sampled during the demonstration using a GeoProbe® or similar equipment. The demonstration itself needed to be sited in a physically accessible area. It would be useful to have background information on the source of fuel contamination and a history of the release.

Information and literature that was reviewed by Battelle provided the following useful facts:

- The Base is situated in the Main River Valley and overlies a large sequence of interbedded, alluvial sand and clay sediments; this alluvium extends to at least 100 m bgs.
- Based on available water level data, the depth to the groundwater table is generally 8 to 9 m bgs.
- Groundwater in the water table aquifer flows laterally to the west/northwest as it approaches and eventually discharges into the Main River.
- The depth to the first laterally extensive confining layer is well below the groundwater table.

It was also determined that little subsurface characterization has been performed to determine if fuel storage and distribution systems at Rhein-Main Air Base are sources of contamination. This lack of characterization presented some significant challenges to the demonstration. First, potential fuel contaminant sources needed to be identified and evaluated to locate an appropriate site and plume for the demonstration. Second, once a plume was selected, the nature and extent of contamination had to be determined as part of the natural attenuation demonstration, and several iterations of sampling and analysis, were needed to delineate a plume. Because there were no suitable, well-delineated plumes readily known and characterized, once a potentially suitable plume was selected, it was necessary to delineate and characterize it while also demonstrating the method for proving natural attenuation.

2. Soil-Gas Surveys

After consulting with Air Base environmental and fuels management staff, Battelle conducted two soil-gas surveys at locations thought to contain fuel contamination. These surveys were

conducted in an effort to locate a plume that was readily accessible and was not being disturbed by the ongoing remedial demonstration that was being conducted by the University of Karlsruhe and Battelle at the former UST site in the POL Yard.

Neither of the two soil gas surveys conducted by Battelle were successful at locating fuel contamination. The first survey was performed in April 1996 behind the Base gas station near the station's USTs. During this survey, eight soil probings were conducted, each to depths of about 3 m. Analysis of soil gas collected from each probe indicated that the oxygen content was too high and carbon dioxide content was too low for fuel contamination to be present. Battelle concluded from these results that there was no plume originating from the Base gas station.

The second survey was performed in July 1996, in the eastern part of the POL Yard, in an area just south of the rail line and east of Theis Road. This area was used for off-loading fuel into the yard from railroad tanker cars. The fuel was piped from this area to various aboveground storage tanks, including several which are no longer present in the yard. Based on his 20 years of experience at the POL Yard, POL Yard Manager Don Zier felt that this site was very likely to be contaminated. However, the soil-gas survey conducted by Battelle was not able to confirm the presence of contamination, so this site was not used for the natural attenuation study.

3. On-Site Consultation

Prior to initiating the groundwater sampling program, Battelle met with hydrogeologists at the Institut Fresenius who were performing site characterization and groundwater monitoring activities across the entire Frankfurt Airport complex and Rhein-Main Air Base. Their study area included the land immediately downgradient to the POL Yard and Base property. The Institut Fresenius staff provided Battelle with background information on groundwater flow, monitoring well construction, and limited data on groundwater chemistry and quality. They were also able to identify other important contaminant sources that are in the general vicinity of the POL Yard plume, and provided Battelle with a copy of the most recent contour map of the water table aquifer for all of Rhein-Main Air Base (Institut Fresenius, 1994). The relevant portion of this map is presented in Figure 32. Battelle also met with several staff members in the Rhein-Main Civil Engineering Group, who were able to identify several potential hydrocarbon sources on Air Base property.

4. Site Selection

Results from the soil-gas surveys and from the information collected from the Institut Fresenius and Rhein-Main Civil Engineering Group did not lead to the discovery of a suitable plume. Because there were no certain alternatives, the POL Yard plume at Rhein-Main Air Base was selected for the natural attenuation study. The source of this plume is the leak from the underground diesel storage tanks and piping at the POL Yard. The soil and groundwater contamination at this plume's source, caused by the leak, are being actively remediated by the University of Karlsruhe and Battelle demonstrations.

For several reasons, Battelle would have preferred to use another plume for this demonstration. Very little was known prior to the start of the natural attenuation demonstration about the nature and extent of contamination caused by this POL Yard source. There was very little known about the history of this fuel distribution system or the time of the leak. There had been no work performed to delineate or characterize the plume. There was also no information on the profile of the

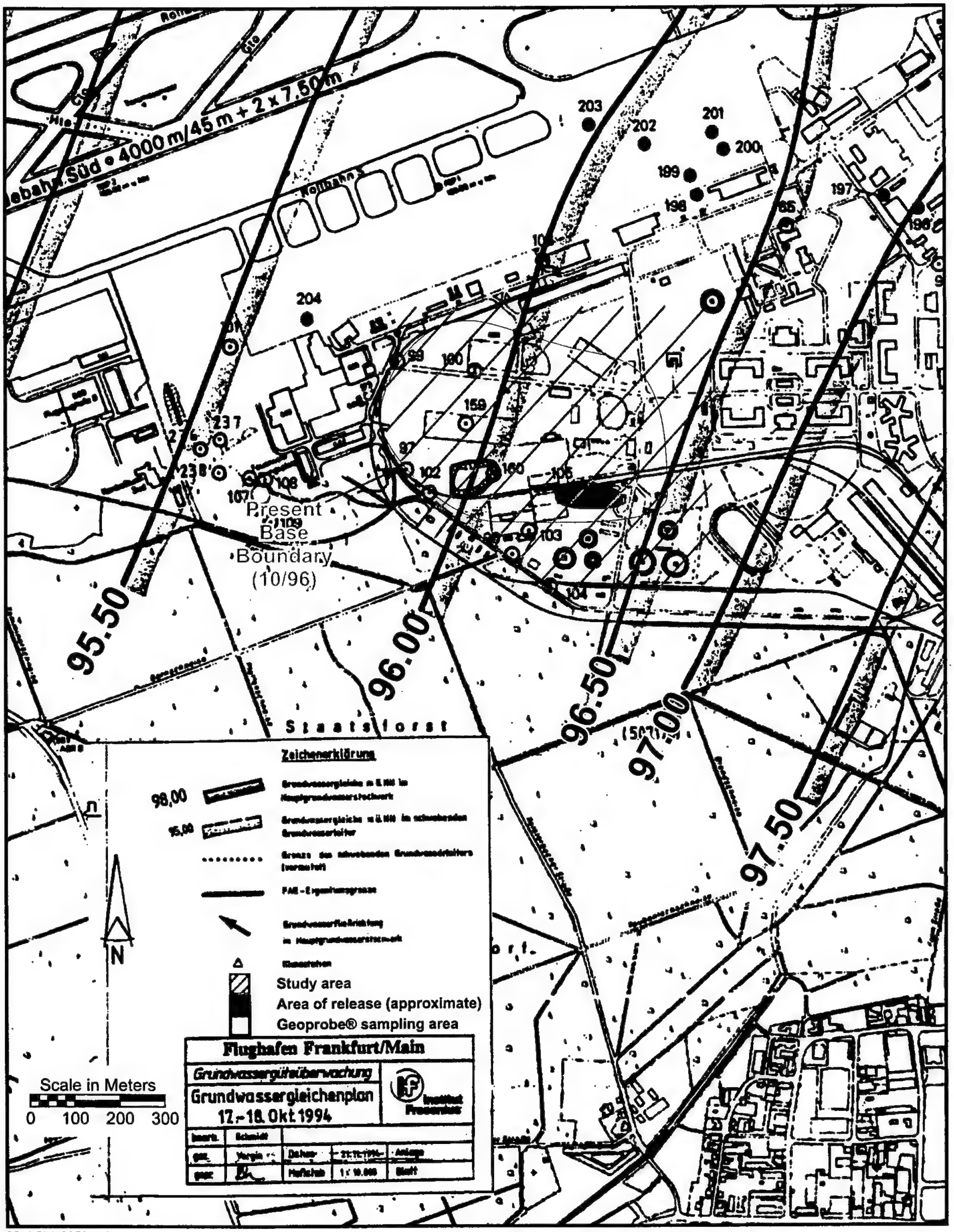

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Figure 32. Water Table Contour Map

plume; the vertical extent and distribution of contamination was unknown. The impact that the ongoing POL Yard remedial demonstrations were having on the plume were difficult to assess. There was uncertainty regarding the history of the area downgradient from the POL Yard source.

A diesel fuel leak is thought to be the POL Yard plume source, although JP-4 jet fuel may have been mixed with this diesel or perhaps also stored separately in the USTs. University of Karlsruhe (Swinianski et al., 1995) reported that JP-4 fuel was possibly added to the diesel during winter months. During the POL Yard demonstrations, it has been proven that the fuel leak contains significant quantities of BTEX, but diesel is not rich in BTEX. The presence of BTEX is important because they are the most common and mobile petroleum hydrocarbon contaminants of concern.

Visual observations made by Battelle indicated that other sources of contamination may be present downgradient of the POL Yard that may have co-mingled with this plume, thus complicating efforts to show that it is attenuating. There are several former and existing features downgradient of the POL Yard that warranted consideration. These features include (1) a former disposal and stormwater runoff catchment basin, (2) a former junk automobile storage compound, (3) a biopile, and (4) various solid and chemical waste storage compounds.

Perhaps the most import of these downgradient features is the former World War II-aged, disposal basin, which has been recently cleaned-up and is now being used as a catchment basin for airfield stormwater runoff. Soils excavated from the bottom of the basin were biopiled adjacent to the site, downgradient from the POL Yard. Very recently, the basin was lined (it was operated unlined for an unknown time period) and an oil-water separator was installed up-line from it to remove hydrocarbons carried by the airfield storm water runoff. Because of its history, this basin could have been a chronic source of groundwater contamination. The former basin or dump, as well as the former excavation and biopile could have impacted groundwater quality by possibly redistributing groundwater recharge, by adding hydrocarbon contamination to the aquifer, by adding or depleting dissolved oxygen to the aquifer, or by adding hydrocarbons or degradation products to the plume.

The junk automobile storage compound and other waste storage compounds that are downgradient from the POL Yard may also be impacting groundwater quality. There were no known releases from these compounds, but given that the soils at Rhein-Main are very sandy and permeable, it is likely that any small spills or releases would eventually impact the aquifer, as there is virtually no surface water runoff from unpaved areas across the Base.

B. SITE CHARACTERIZATION TO DEMONSTRATE NATURAL ATTENUATION

Site characterization activities conducted as part of the natural attenuation study were patterned on those recommended in the U.S. Air Force Protocol for natural attenuation studies (Wiedemeier et al., 1995). The site characterization was designed to evaluate the nature and extent of petroleum contamination in groundwater as well as to determine if evidence of natural attenuation, and specifically intrinsic biodegradation, is present. Intrinsic biodegradation is the most important of several natural processes at play within a plume that is undergoing natural attenuation. It is most important because it is the only one of several natural attenuation processes that transforms contaminants into innocuous byproducts and reduces the total mass of contaminants in the subsurface.

A reduction in plume concentration is generally considered evidence of natural attenuation, provided that it is known that the plume source is being removed and that the plume is not increasing

in size. Evidence of intrinsic biodegradation is found by collecting groundwater quality data from points scattered across the area of the plume, from points within the source area, and from non-impacted upgradient locations.

Site characterization activities focused on collecting two temporal data sets to (1) determine the nature and extent of a plume caused by a release of petroleum-related contamination and (2) collect specific water quality parameters directly related to the intrinsic biodegradation of the plume. The second data set was collected two years after the first to determine if the levels of contamination were dropping over that two-year time period and if water quality parameters and concentrations of compounds related to intrinsic biodegradation were concurrently following anticipated trends.

Specific details concerning on-site activities are described in the following sections. Appendix H contains photographs of key on-site activities and site features related to the natural attenuation analysis.

1. Overview of On-Site Activities

The first phase (Phase 1) of data collection and analysis took place from September 30 through October 16, 1996. Two Battelle staff members, a hydrogeologist and a water quality technician, traveled at that time to Rhein-Main Air Base to collect the first of two sets of contaminant and water quality data. This effort consisted of setting up on-site analytical capabilities (Hach® kits and a gas chromatograph) at the site, finalizing the approach to collect the groundwater samples, and collecting samples using a subcontracted GeoProbe® unit and its two-person operating crew. To gain clearance from utility and unexploded ordnance (UXO) hazards, Battelle delineated an area thought to envelop the area of contamination and identified 25 locations where GeoProbe® sampling would likely provide data on contaminant concentrations or on the presence and concentration of degradation byproducts originating from the contaminants. Figure 33 contains the site map and the Phase 1 GeoProbe® sampling locations.

The second phase (Phase 2) of data collection and field analysis took place from September 22 through October 2, 1998. Two Battelle staff members returned to the site to determine and evaluate any changes that had taken place in the plume and groundwater since the first phase. The same GeoProbe® and sampling equipment were used in similar fashion to the first sampling event, but an improved, more easily used water quality meter and a flowthrough cell were deployed.

2. Study Area Features and Plume Delineation

Prior to the Phase 1 sampling, the study area or sampling area was delineated based on knowledge of the direction of groundwater flow across the source area, and on general knowledge of how a typical hydrocarbon plume might have formed. The study area had a downgradient constraint because sampling could only be performed within the confines of the Air Base. The distance from the source to the downgradient boundary of the Air Base is about 550 m.

Some potentially significant changes to site features occurred between the first and second sampling phases. The disposal basin located downgradient of the POL Yard plume present during Phase 1 was lined and upgraded to the existing airfield catchment basin before Phase 2. The biopile containing excavated soils from the disposal basin (another downgradient feature) that was in place during Phase 1 was removed prior to Phase 2. Construction of an oil-water separator was completed

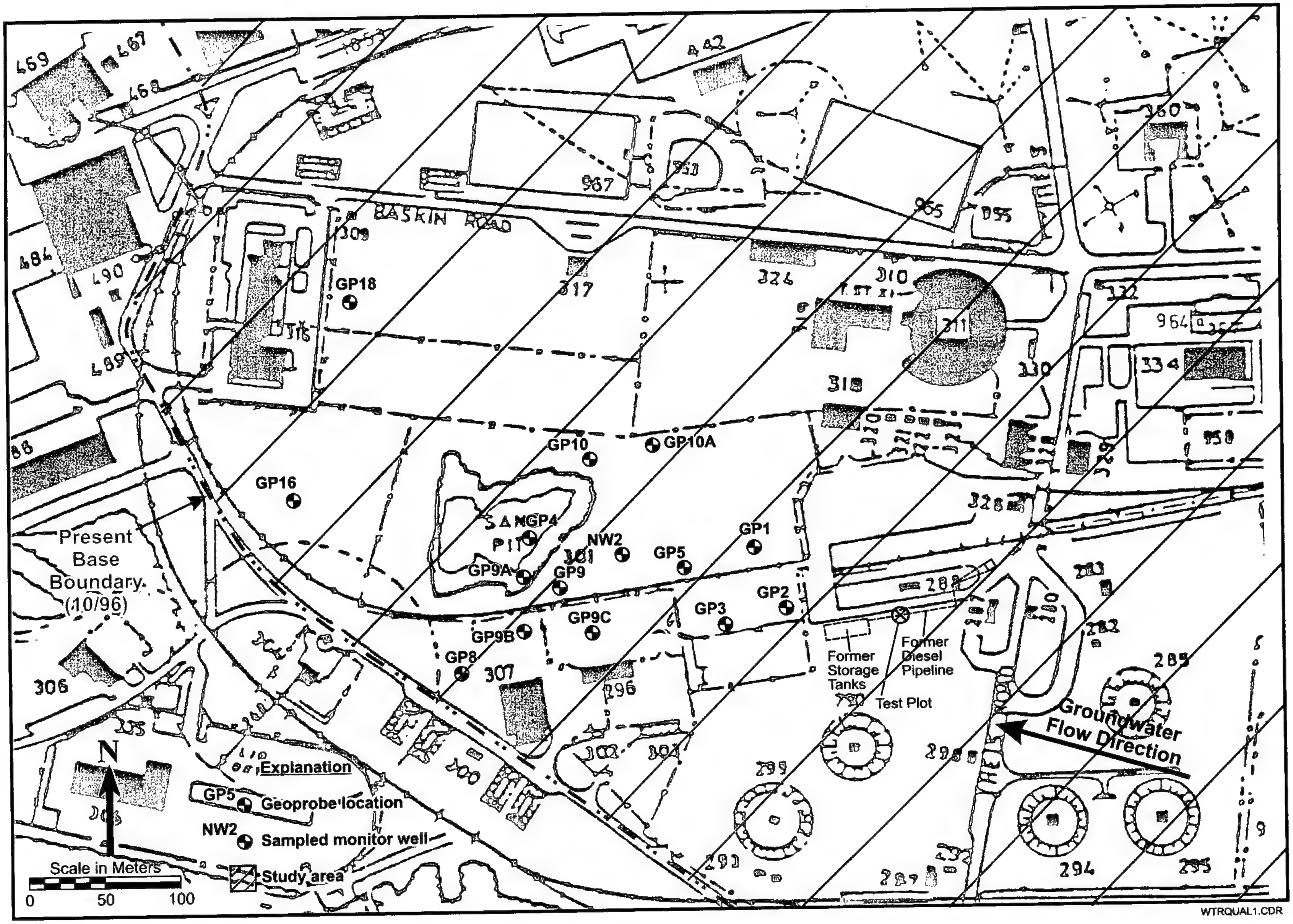


Figure 33. Site Map Showing Phase 1 Geoprobe® Sampling Locations

between the two sampling phases. These changes may have impacted local groundwater quality between the sampling phases.

3. Sampling Locations and Clearance

Digging permits were obtained for probing prior to the start of both survey phases. All probing locations were pre-cleared for buried utilities and UXO. The UXO clearance was necessary because the study area was bombed extensively by Allied Forces during the latter part of World War II. A total of 25 locations were cleared for probing before each sampling phase. During each phase, probing locations were staked in the field and spotted on a site map, but not surveyed. Painted wooden stakes, marking each of the 25 cleared locations were used to guide the GeoProbe® crew from location to location, as sampling progressed during each phase. Because of the two-year time period between sampling events, the locations staked during Phase 1 could not be maintained for Phase 2. But the map of the Phase 1 sampling locations was used to guide the placement of Phase 2 sampling locations. Figure 33 shows the Phase 1 sampling locations; Figure 34 shows the Phase 2 sampling locations.

During Phase 1, GP-18 was the farthest downgradient sampling point, located 400 m northwest of the POL yard source. The closest sample point was GP-2, some 25 m downgradient and west of the source. Because field time was limited and there was a need to focus on delineating the plume, no upgradient or cross-gradient samples were collected during Phase 1. During Phase 2, GP-17, -20, and -21 were the farthest downgradient sample points from the source, they are located from 465 m to 515 m northwest of the source. During Phase 2 one sampling point (GP-23) was located 210 m upgradient and east of the source, and one crossgradient sample point, (GP-25), was located 250 m north of the source.

4. Groundwater Sampling and Analysis

During the first sampling phase, Battelle staff used the GeoProbe® to sample groundwater at a total of 14 of the 25 cleared locations. Groundwater at these locations was analyzed at the site using YSI field instruments (Model 3500) and a separate dissolved oxygen probe (Model 55), Hach® analytical kits, and a portable GC. During the second sampling phase, at the 23 Geoprobed locations, a total of 31 groundwater samples were retrieved for analysis. Groundwater samples were also collected at monitoring wells MW1, -2, and -3 at the Battelle test plot within the POL yard.

During Phase 2, groundwater was analyzed for various attenuation-related parameters using a YSI Model 6820 instrument. Hach® kits were used to analyze for other relevant water quality parameters. While Phase 1 samples were analyzed on site using a portable gas chromatograph, Phase 2 samples were collected in 40 mL volatile organic analysis (VOA) vials and shipped to Alpha Analytical, Inc., a U.S. EPA-certified laboratory in the United States to be analyzed for BTEX and TPH constituents. Eliminating the on-site GC work during Phase 2 enhanced the process of data collection and analysis because it enabled more time to be spent on measuring specific water quality parameters using the Hach® kits.

The Phase 2 analyses by a certified laboratory included initial runs for both TPH purgeable and extractable analyses. As was the case during Phase 1, results from the two types of TPH analyses on POL Yard groundwater samples indicated that purgeable (BTEX-rich) constituents were predominant at the site. The TPH results imply that JP-4 is the predominant contaminant, rather than

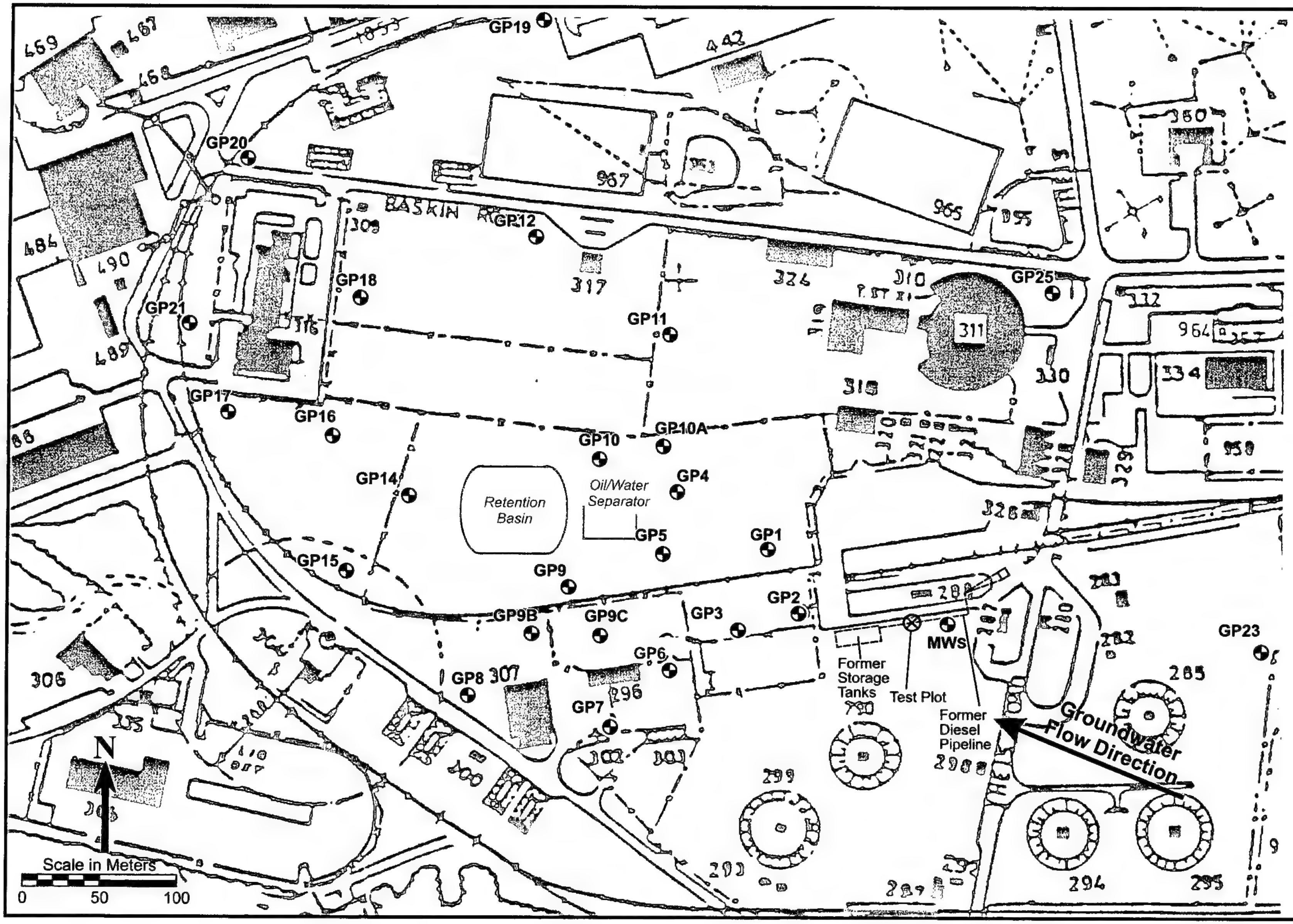


Figure 34. Site Map Showing Phase 2 Geoprobe® Sampling Locations

diesel. Because the source was found to be rich in BTEX, TPH-purgeable analyses were run on all Phase 2 downgradient samples collected by the GeoProbe®.

a. Probe Head Measurements

During both phases of sampling, a GeoProbe® Model 4220 was used to physically drive sampling rods to depths of approximately 10 m. The 4220 unit consists of a Kawasaki 4-wheel drive utility vehicle (or "mule") with a GeoProbe® GH-40 hydraulic-driven percussion hammer mounted on the back. This unit is capable of driving assemblies of 1.0-inch outside diameter (O.D.) (0.5-inch inside diameter (I.D.) threaded hollow steel rods and tip-mounted sampling tools to depths as great as 40 m, in the most favorable geologic settings. At the Rhein-Main Air Base site, the unit was able to drive rods to below the water table at all but one of the cleared locations, where refusal occurred at about 5 m bgs. Based on water level data collected from monitor wells that are present in and around the area, the depth to groundwater was known to be approximately 8 to 8.5 m bgs. To be effective at retrieving sufficient groundwater, it was determined during the study that the GeoProbe® needed to be driven to a depth of at least 9 m. Some sampling was attempted at depths between 8.5 and 9.5 m, but most of the probings were driven to a depth of approximately 10 m so that there was enough groundwater flowing into the screen to lift it efficiently for sampling and parameter measurement.

During Phase 2, probes were driven to a depth of 10 m to streamline the sampling process at all locations by setting a target sampling depth that is sufficient to readily collect groundwater within the zone of contamination. Given that the plume source is a light, non-aqueous phase liquid (LNAPL), a shallow plume was expected. Interbeds, which is typically present within sandy deposits, would help to keep the plume shallow. Because field time was limited, it was not possible to collect samples from several depths at all locations.

At three locations, GP-1, GP-3, and GP-5, in addition to sampling at a depth of 10 m, samples were collected from greater depths to determine if the plume was extending deeper into the aquifer. At these three locations, samples were also collected at 14 m. However, efforts to collect samples from depths greater than 14 m were inhibited by GeoProbe® refusals. At GP-1, a sample was also collected at 17 m, where refusal occurred. GP-3 was successfully probed to 16 m before refusal, so a sample was collected at that depth. The refusals were apparently occurring at depths where the GeoProbe® was encountering gravel zones too thick and dense to penetrate.

Groundwater was sampled from the GeoProbe® rod assembly using a retractable screen point sampler that was placed ahead of the rods (Figure 35). The screen point sampler is exposed to the aquifer by retracting the drive rods that are above it once the assembly is driven below the water table. Groundwater was lifted to ground surface by inserting ⅜-inch O.D. × ¼-inch I.D. polyethylene tubing inside the hollow rods to the base of the screen point and using either a peristaltic pump or a Waterra® pump to lift the groundwater above ground. When available, the Waterra® pump was generally used at locations where groundwater was too deep to lift with the peristaltic pump. During Phase 2, only the Waterra® pump was used to collect groundwater. Cavitation was generally not experienced because the screen bottom was set at 10 m, creating a high enough water column to keep the tubing completely submerged during pumping. Cavitation is undesirable because it possibly can bias concentrations of volatile fuel constituents and dissolved oxygen.

Once the screen and hollow rods had been driven by the GeoProbe®, generally to a depth of 10 m, groundwater was pumped through polyethylene tubing from the screen and up the GeoProbe®

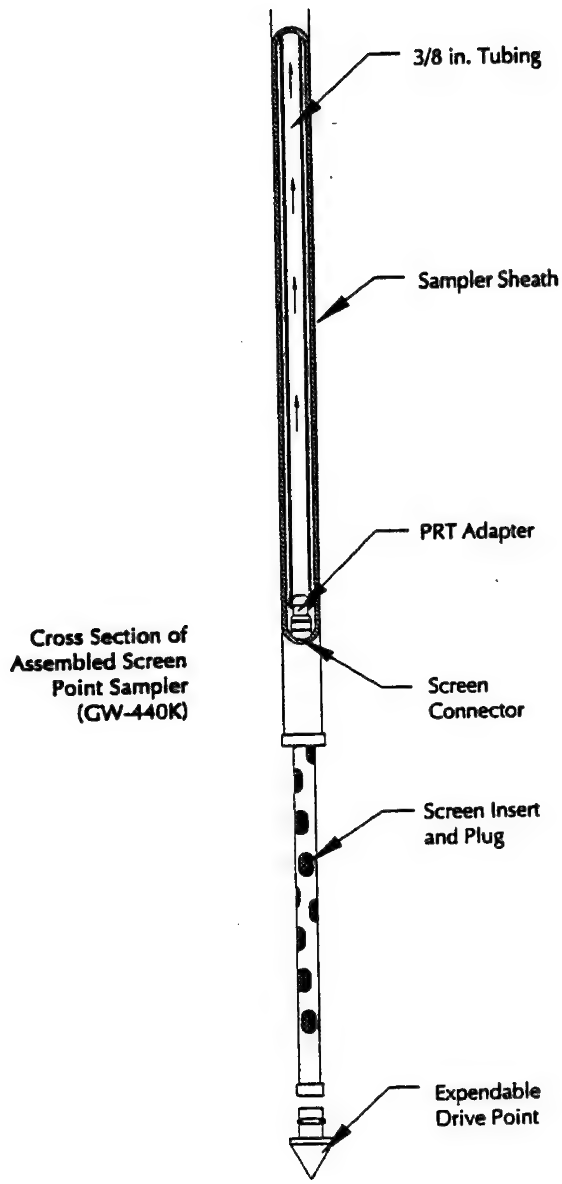


Figure 35. Schematic Diagram Showing Details of the GeoProbe® Screen Point Sampler

rods to the probe head. The pumped groundwater was then channeled in the tubing through a flow cell that was attached to the YSI multi-parameter water quality instrument probe. The YSI measures groundwater temperature, conductivity, pH, and oxidation/reduction potential (Eh). During Phase 1, once these parameters had been measured at a given location, dissolved oxygen (DO) was also measured by disconnecting the flow tube from the flow cell and inserting it into a small glass Erlenmeyer flask. The DO probe was then placed inside the flask and groundwater was circulated through the beaker until the instrument measured a stable DO value. As readings were being taken, groundwater was always circulating through the flow cell and the Erlenmeyer flask. The rate of circulation varied from location to location, depending in part on how much groundwater any given probing would yield. The average circulation rate was about 80 mL/minute, and the rate was never less than approximately 20 mL/min. During Phase 2, a Model 6820 YSI instrument was used to collect DO within the flow cell along with the other parameters. Since the groundwater is not exposed to air when a cell is used, this is a more efficient and possibly more accurate method for measuring DO.

The instruments that were used to measure water quality parameters were manufactured by Yellow Springs International (YSI) located in Yellow Springs, Ohio. During Phase 1, the YSI Model 3500 meter was used to measure the four flow cell parameters (temperature, conductivity, pH, and Eh). The YSI 3500 meter was calibrated at the start of the six-day GeoProbe® survey and then three days later at the survey's mid point. The calibration procedures that were utilized are presented in the instrument's operator's manual. According to YSI's recommended procedure, the YSI 55 DO meter was calibrated every time it was used.

During Phase 2, a YSI 6820 instrument was used to monitor water quality parameters at the probe head. In addition to having all of the capabilities of the Model 3500, this probe can also measure dissolved oxygen. During Phase 2, the YSI 6820 instrument was calibrated daily for DO, pH, conductivity and Eh readings. At night, the meter was stored on site in the Battelle field trailer. Its power supply was recharged every evening.

At each well head, once stable water quality readings were measured, a set of groundwater samples was collected so that additional analyses could be made at the trailer. The pump and tubing were used to fill two 40-mL, chemically clean sample vials to determine BTEX concentrations in the groundwater. A 500-mL flask was filled to collect sulfide, sulfate, manganese, ferric iron, and nitrate measurements.

b. Other On-Site Analyses

The Phase 1 on-site GC was a Model 8610, manufactured by SRI Instruments, Inc. of Las Vegas, NV. BTEX standards were used to calibrate the GC, and helium was used as the carrier gas. The standard was prepared daily by adding 20 μL of 2 ppm BTEX solution to 10 mL deionized water to generate a 4-ppb level standard. Groundwater samples were compared to the known standard to determine the amount of BTEX contained within a sample. If a peak was found within 0.2 second of the retention time of the standard, then the parameter was considered as a positive detection and the value of the area of the peak was recorded. Because of the low level of BTEX in the standard, samples suspected of containing a high level of BTEX were diluted with deionized water. The dilution factor was then used when calculating BTEX concentration. Between sampling, blanks were run to purge the GC. The decision to dilute any sample was based on sample location (distance from the source) and odor (presence or absence of fuel odors in the groundwater).

During both the Phase 1 and the Phase 2 sampling events, a set of Hach® analytical kits were used to measure the content of other electron acceptors and biological degradation byproducts such as sulfide, sulfate, manganese (Mn II), ferric iron (Fe III), and nitrate. When samples could not be analyzed immediately following collection, the samples were stored in coolers containing ice packs until the time of analysis. Turbid groundwater samples were filtered using filter paper and a funnel. For groundwater containing ferrous iron (Fe II), concentrations exceeding 5.0 mg/L or sulfate concentrations exceeding 10 mg/L, the sample was diluted with deionized water so that the sample would fall within the limits of the Hach® colorimeter calibration modules. The dilution factor was then factored into the concentration calculation. The procedures that were applied with the Hach® kits are contained in the Hach® colorimeter manual. Prepared standards for nitrate, manganese, and sulfate were used to check the accuracy of the methods.

C. RESULTS FROM GROUNDWATER ANALYSES

1. Summary of Groundwater Quality and Contamination

The parameters that were measured during both phases of the field survey have been tabulated and mapped. Appendix G contains all of the water quality data measured (1) at the probe head, using a YSI meter; (2) on-site, using a Hach kit and/or field GC; and (3) with a GC located at Alpha Analytical, Inc.'s laboratory in the United States. These tables contain all data collected during both phases of the field groundwater survey for the natural attenuation study. All of these data originated from groundwater samples that were collected with the GeoProbe® except samples collected from locations NW-2 and MW-1, -2, and -3. NW-2 was a preexisting monitoring well that is located northwest of the POL Yard. Battelle installed the MW monitoring wells within the POL Yard as part of the POL Yard bioremediation demonstration.

Both the 1996 and the 1998 data sets were mapped to determine if trends in the distribution of TPH or BTEX contamination and in natural attenuation are observable. Figure 36 is a contour plot depicting the distribution of TPH in September 1998. Figures 37a and b through 51a and b depict the September 1996 and September 1998 distributions of the following fuel components or attenuation parameters: benzene, toluene, ethylbenzene, *m*-, *p*-xylene, *o*-xylene, DO, oxidation/reduction potential, nitrate, sulfate, Fe II, manganese, sulfide, conductivity, temperature, alkalinity, and pH. Information on these components and parameters are presented and discussed in the sections that follow, along with interpretations of the data concerning the nature and extent of contamination and on evidence of natural attenuation.

In addition to contour maps that show the distribution of contaminants and water quality parameters, two sets of x-y plots (concentration versus distance) were developed to evaluate data collected during the two sampling phases. The plots were used to help evaluate the spatial trend of the contaminants and various attenuation parameters using a transect oriented along the direction of plume migration (the plume's major axis), which conforms with the direction of groundwater flow. This transect starts at the upgradient GP-23 location (Phase 2 only), traverses the POL Yard source, and proceeds past various GeoProbe® locations until it reaches the Base boundary located about 500 m northwest of the source. Since the exact locations of GeoProbe® locations differed between the two phases, the locations used on the transect for Phase 1 data varied slightly from the locations used on the transect for the Phase 2 data. Figures 52 and 53 depict the layout of Phase 1 and 2 transects across a map of the study area.

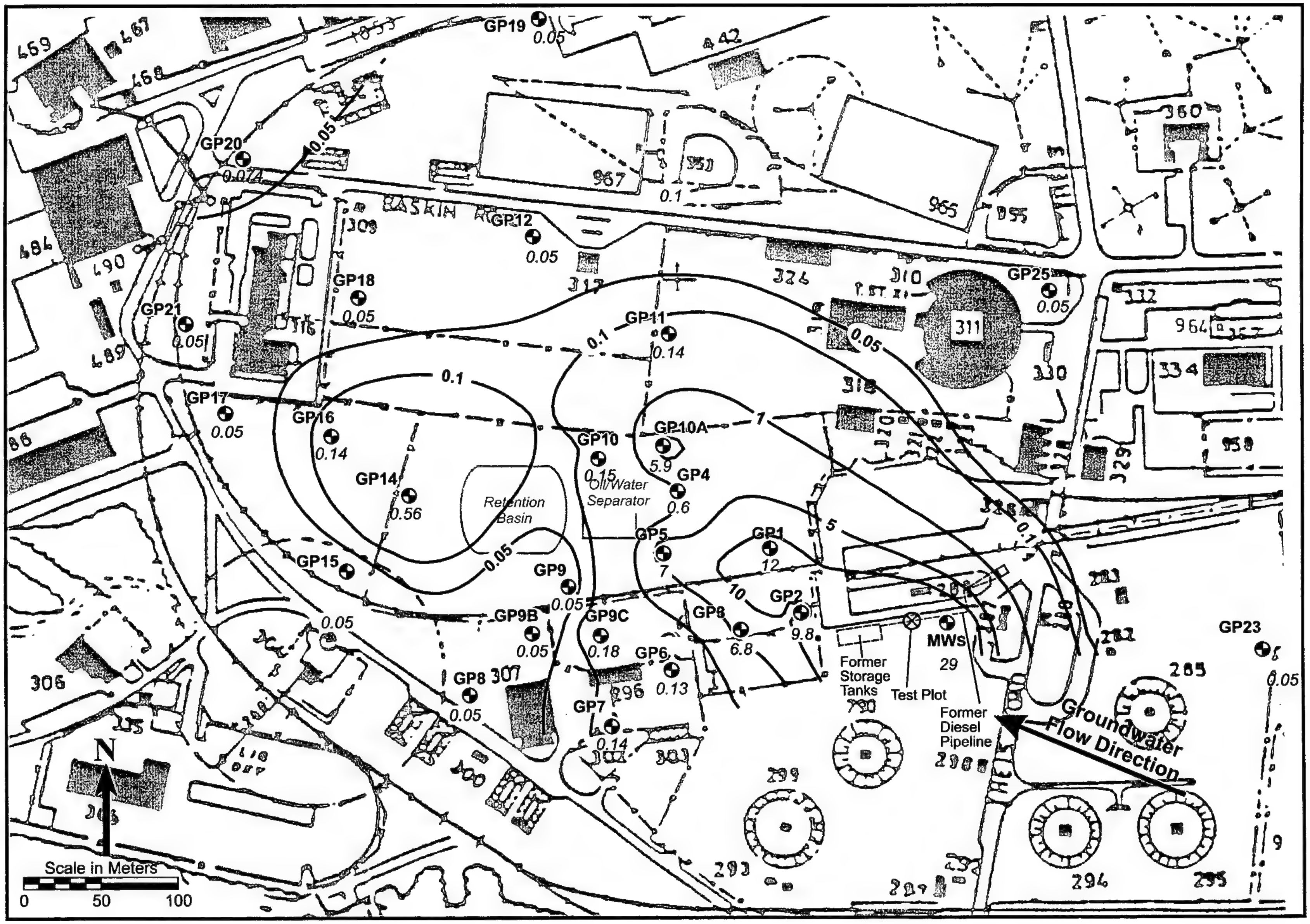


Figure 36. TPH-Purgeable Distribution (mg/L) – 1998

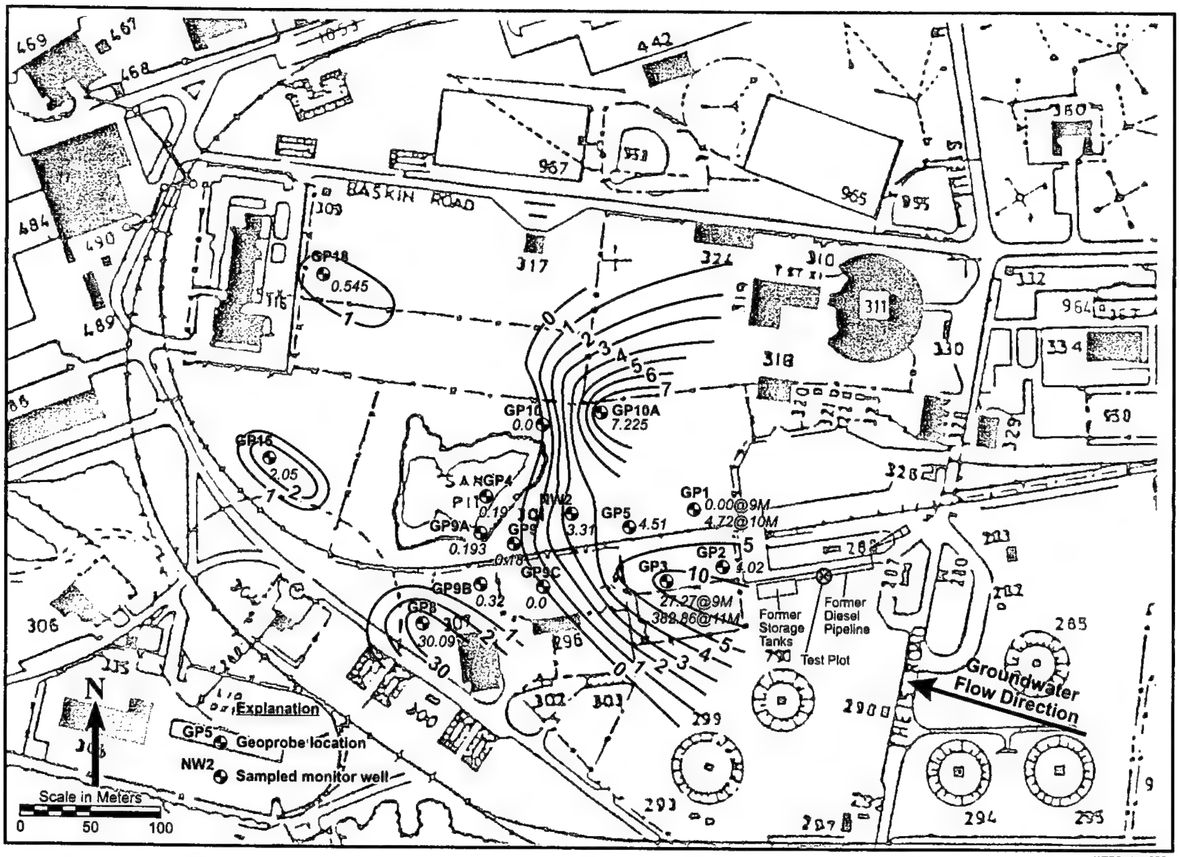


Figure 37a. Benzene Distribution (µg/L) – 1996

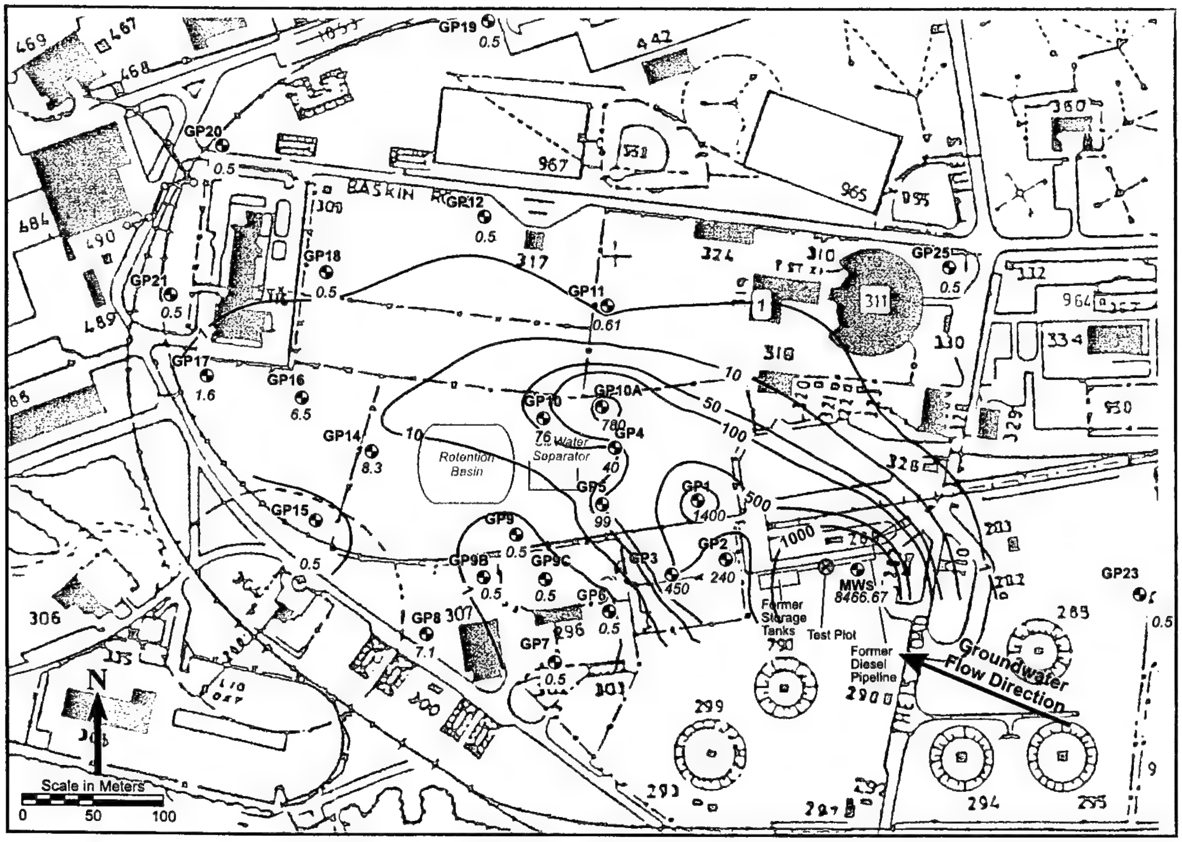


Figure 37b. Benzene Distribution (µg/L) – 1998

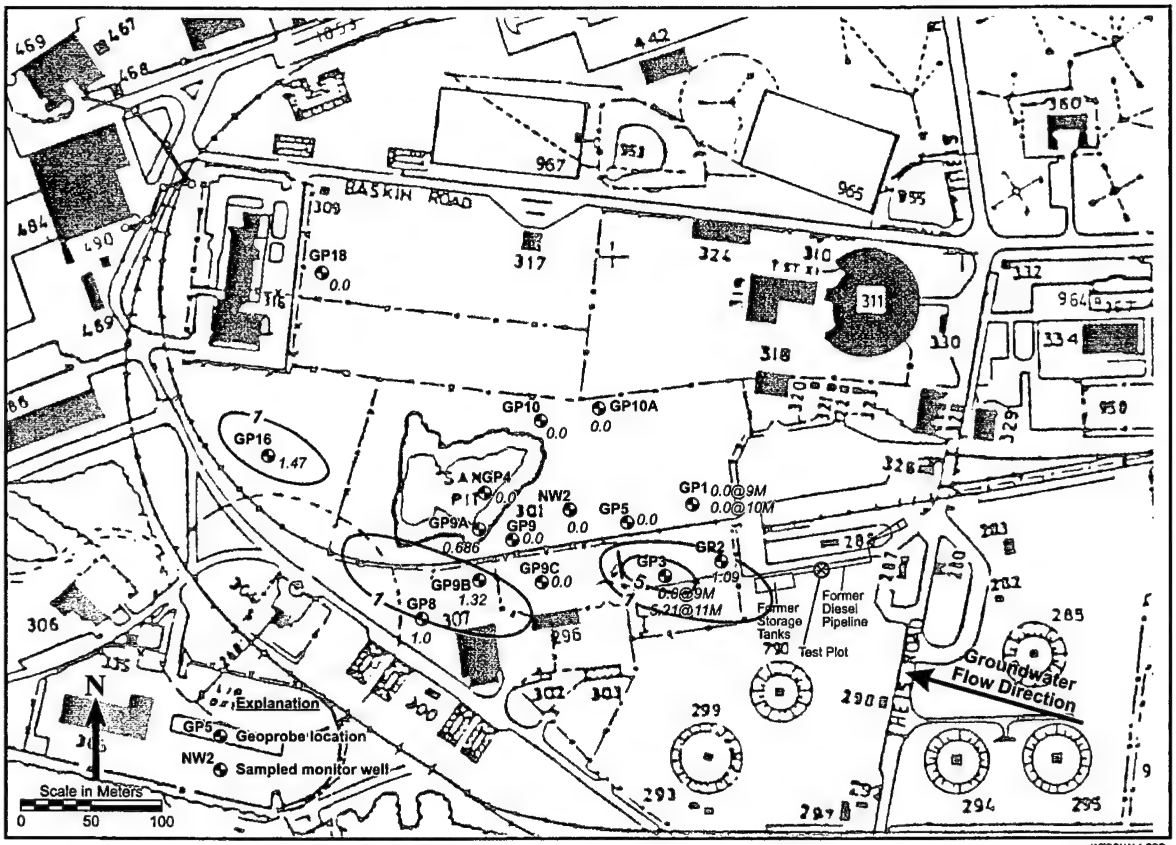


Figure 38a. Toluene Distribution (µg/L) – 1996

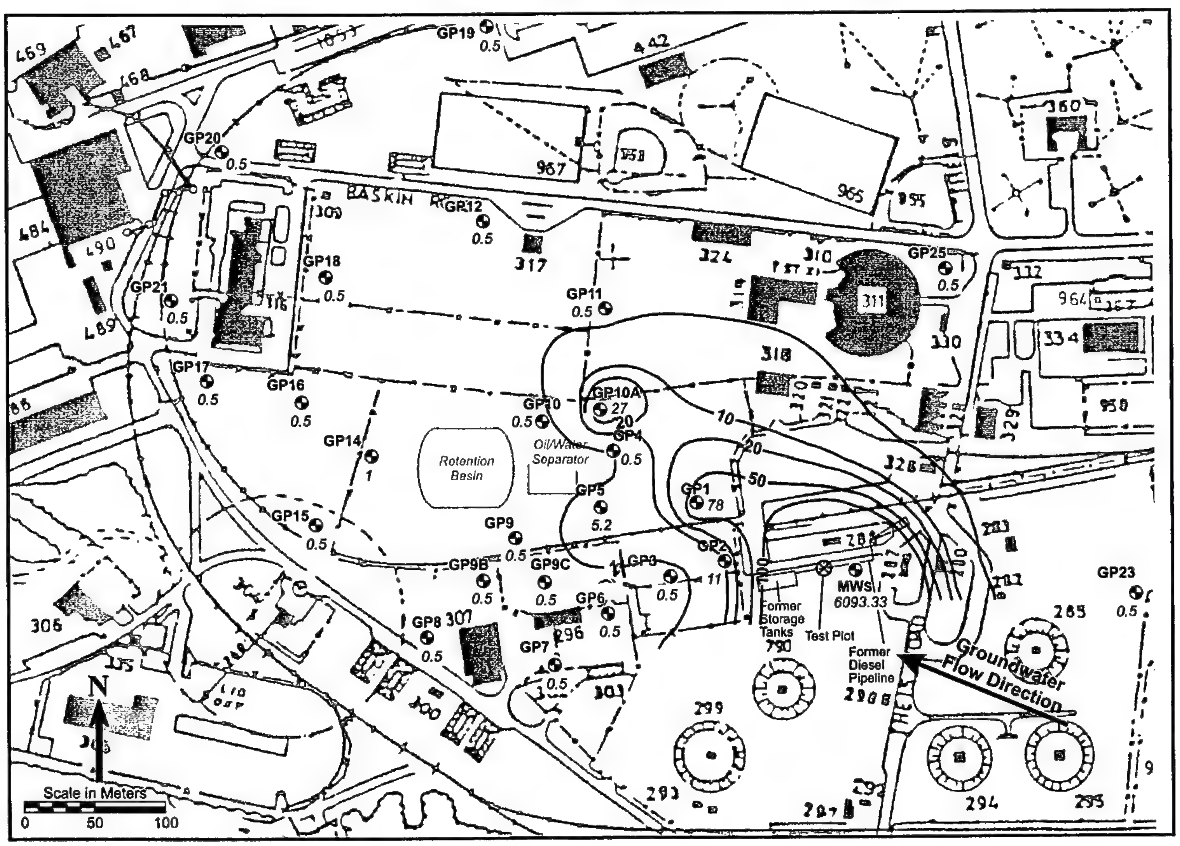


Figure 38b. Toluene Distribution (µg/L) – 1998

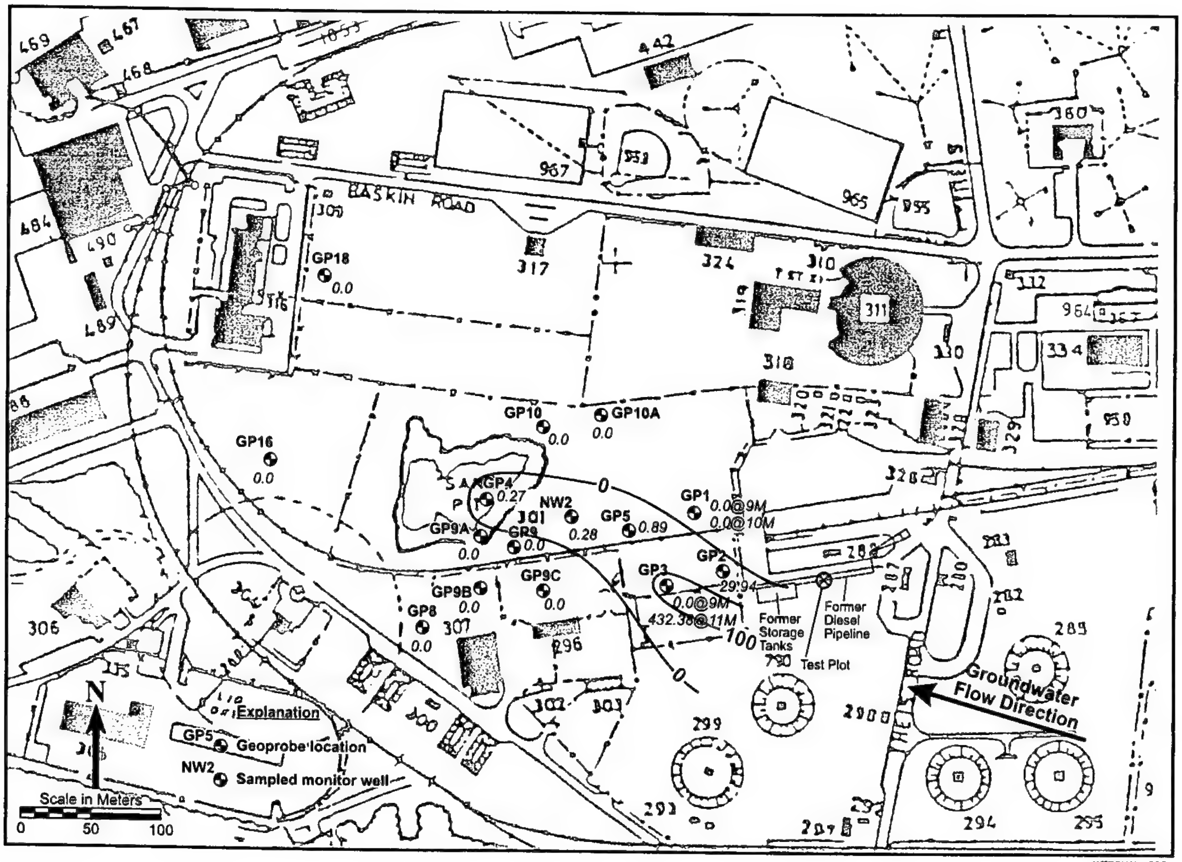


Figure 39a. Ethylbenzene Distribution (μg/L) – 1996

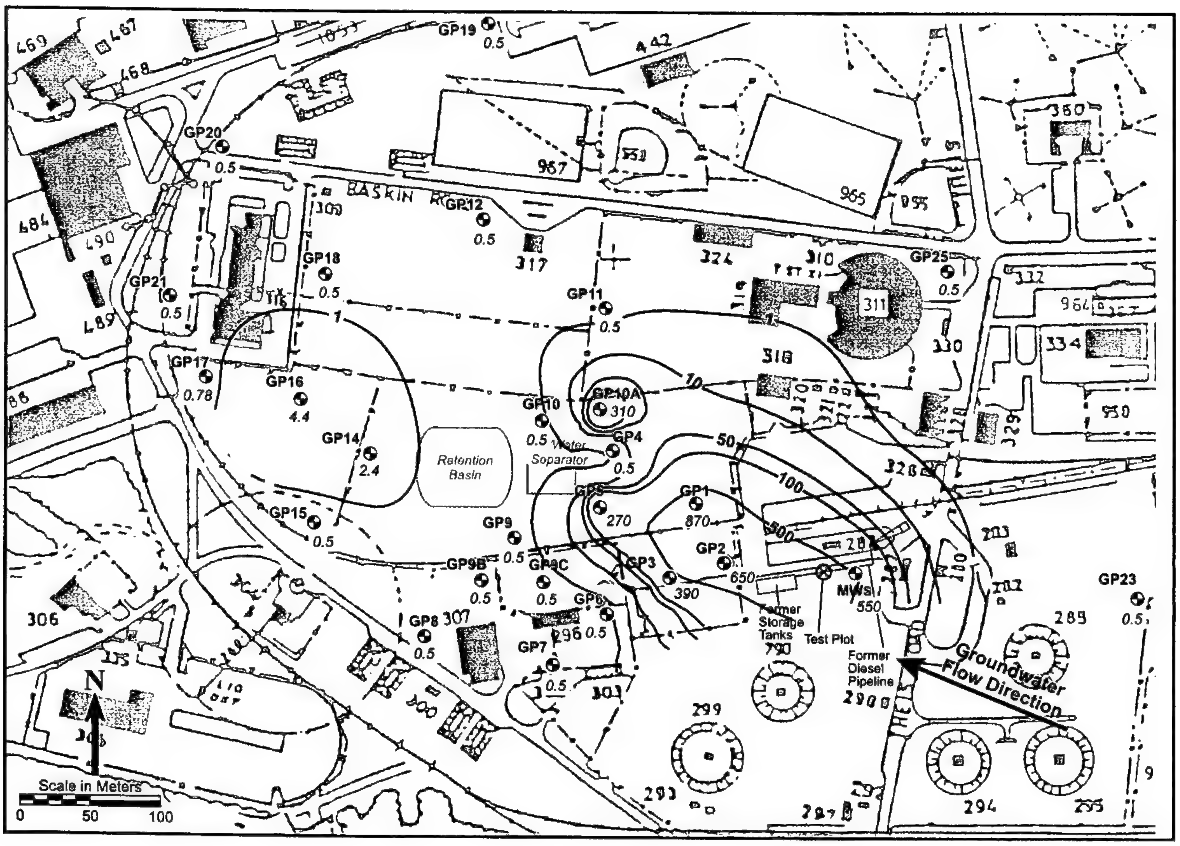


Figure 39b. Ethylbenzene Distribution (μg/L) – 1998

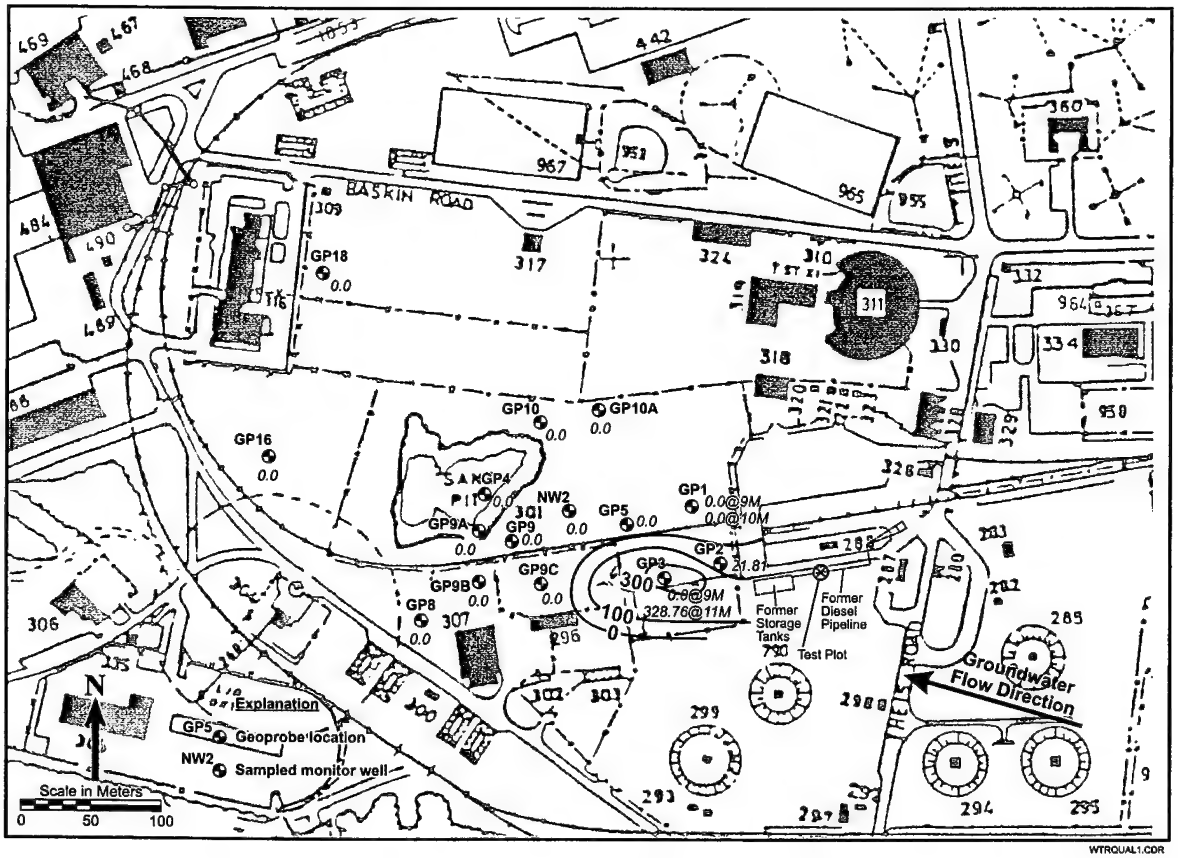


Figure 40a. ***m,p*-Xylene Distribution (µg/L) – 1996**

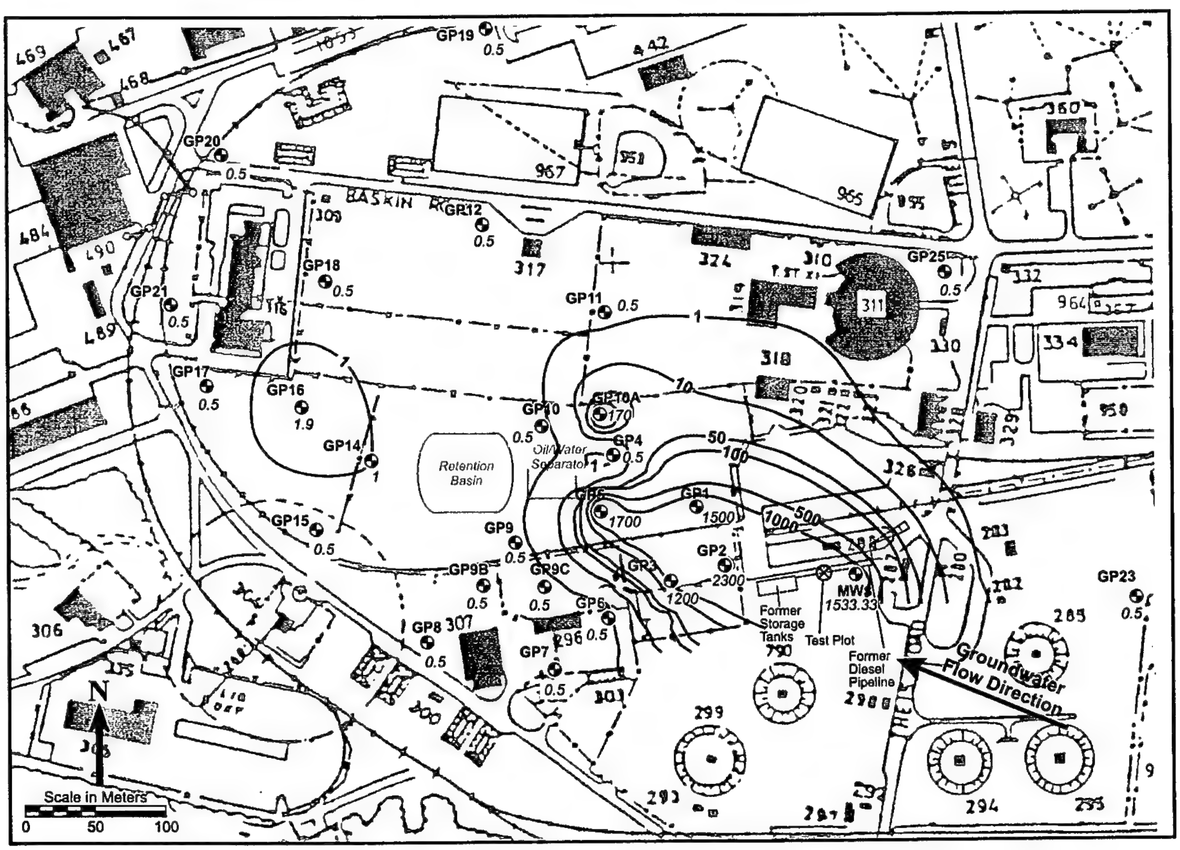


Figure 40b. ***m,p*-Xylene Distribution (µg/L) – 1998**

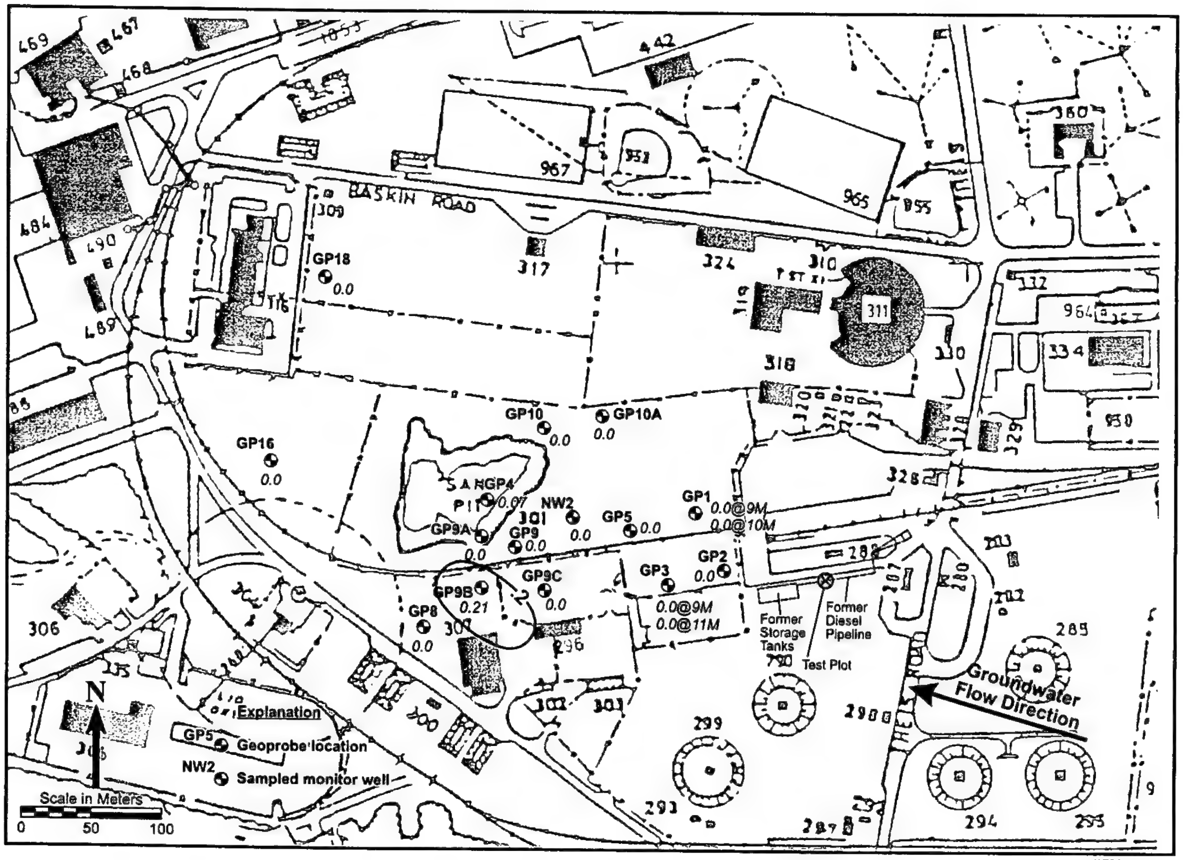


Figure 41a. *o*-Xylene Distribution (µg/L) – 1996

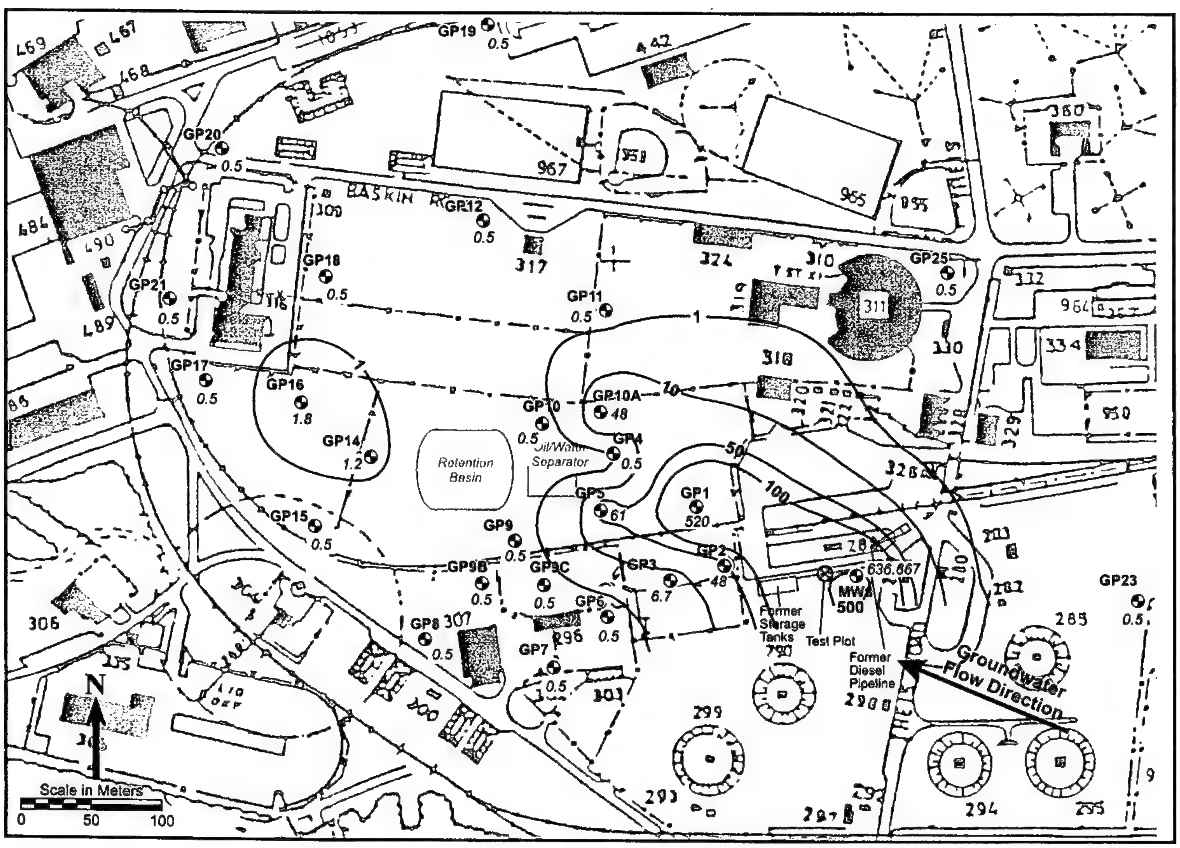


Figure 41b. *o*-Xylene Distribution (µg/L) – 1998

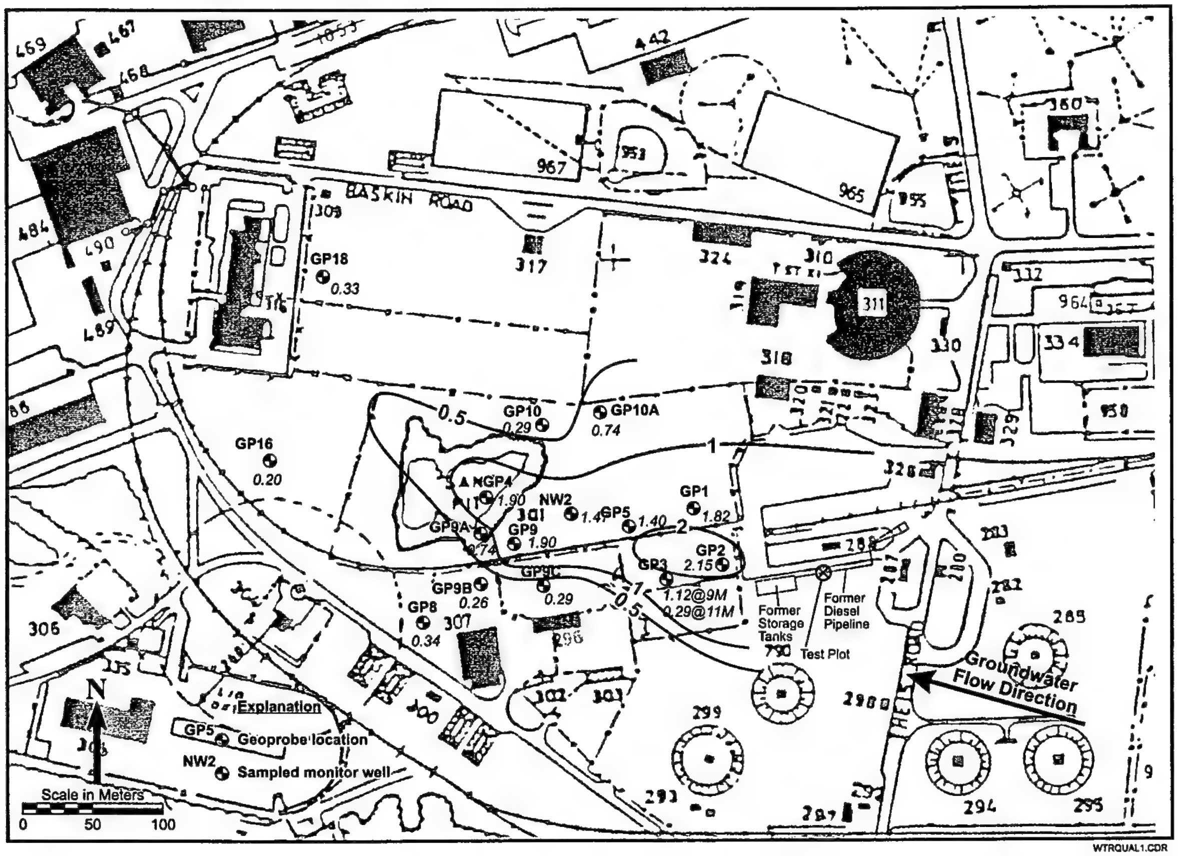


Figure 42a. Dissolved Oxygen Distribution (mg/L) – 1996

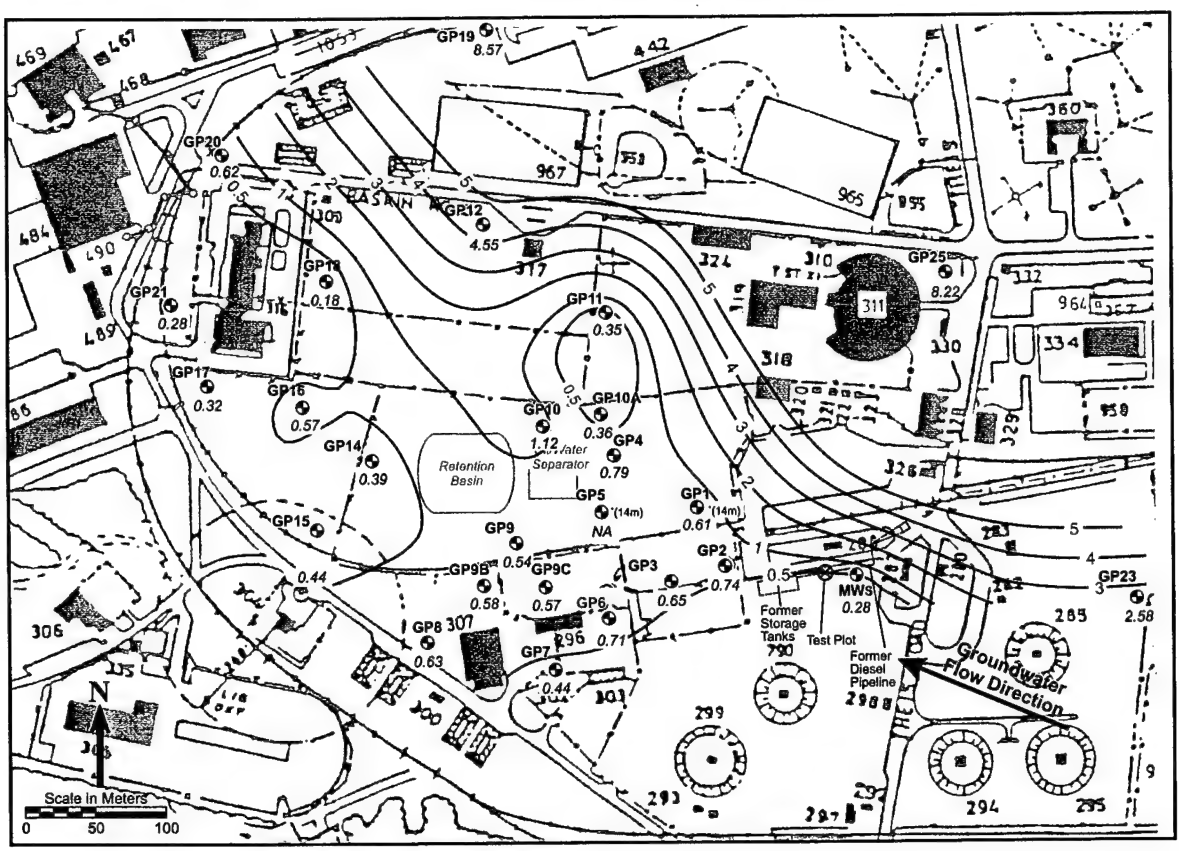


Figure 42b. Dissolved Oxygen Distribution (mg/L) – 1998

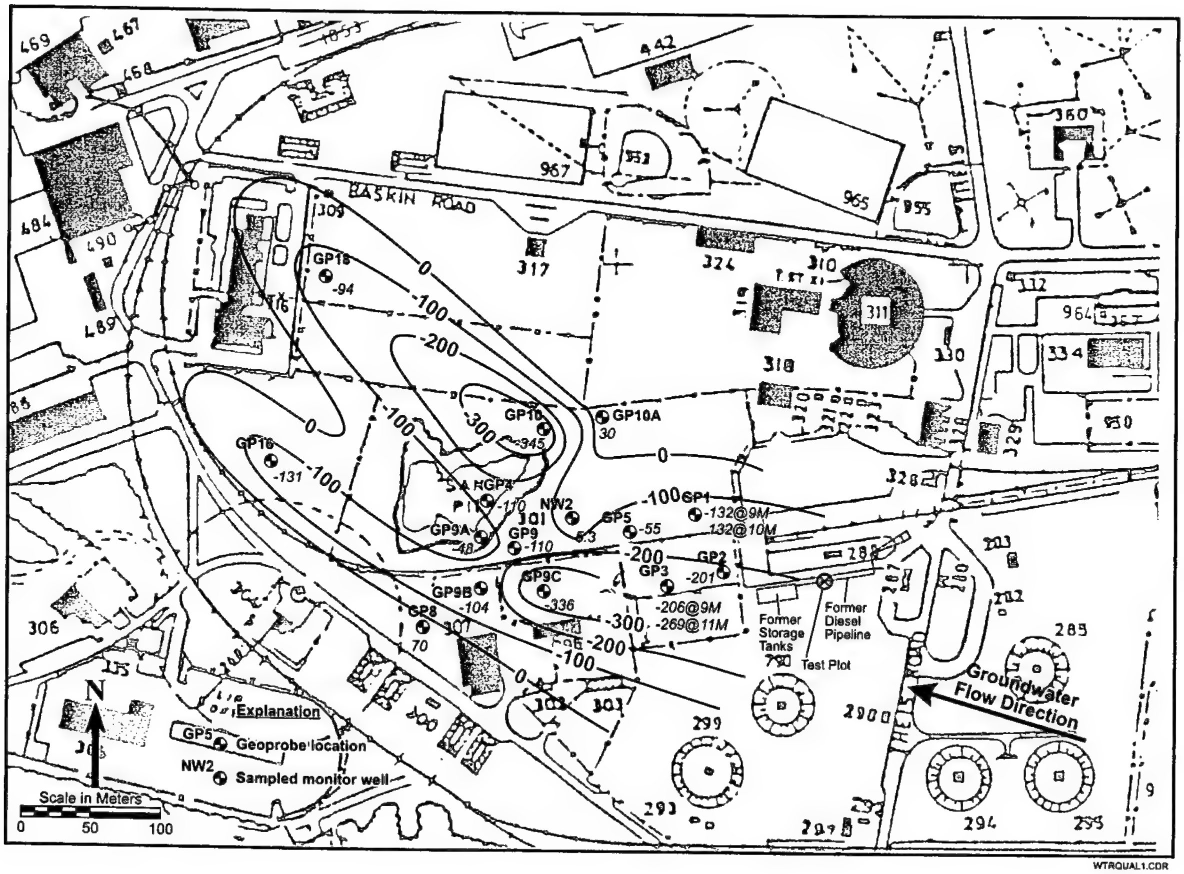


Figure 43a. Oxidation/Reduction Potential Distribution (mV) – 1996

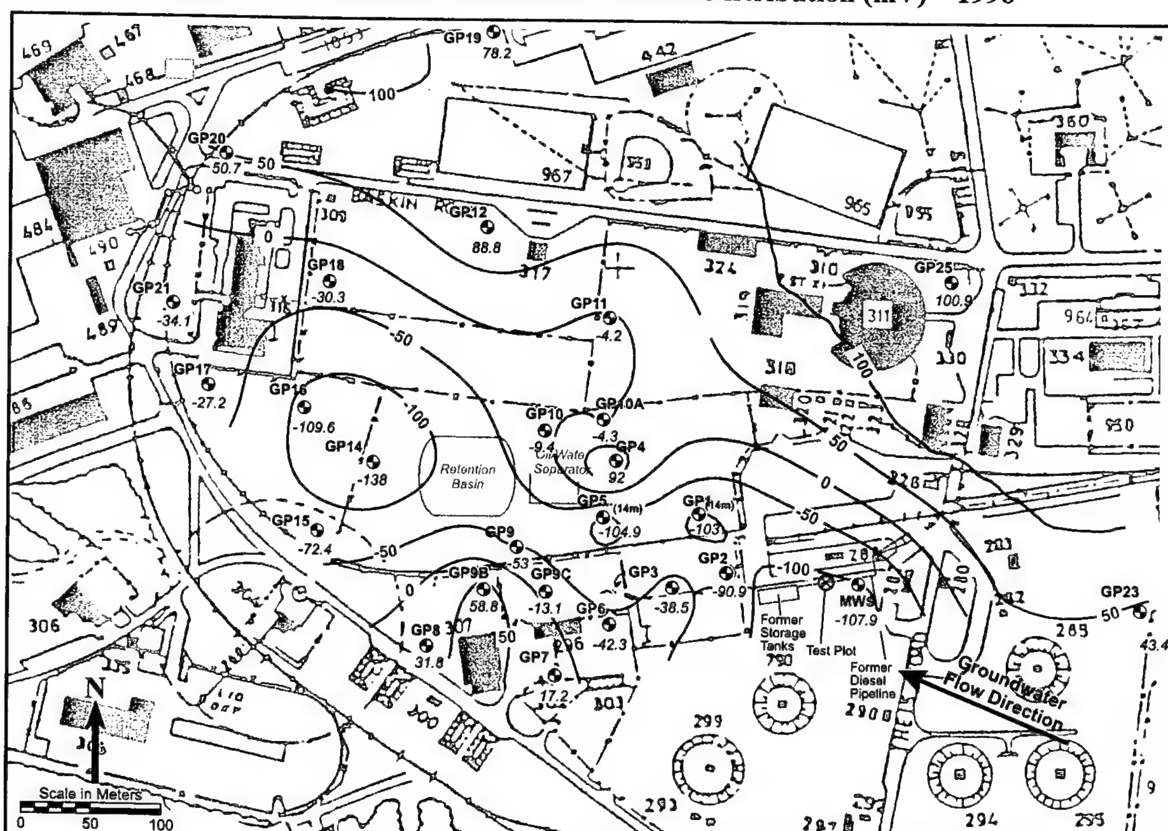


Figure 43b. Oxidation/Reduction Potential Distribution (mV) – 1998

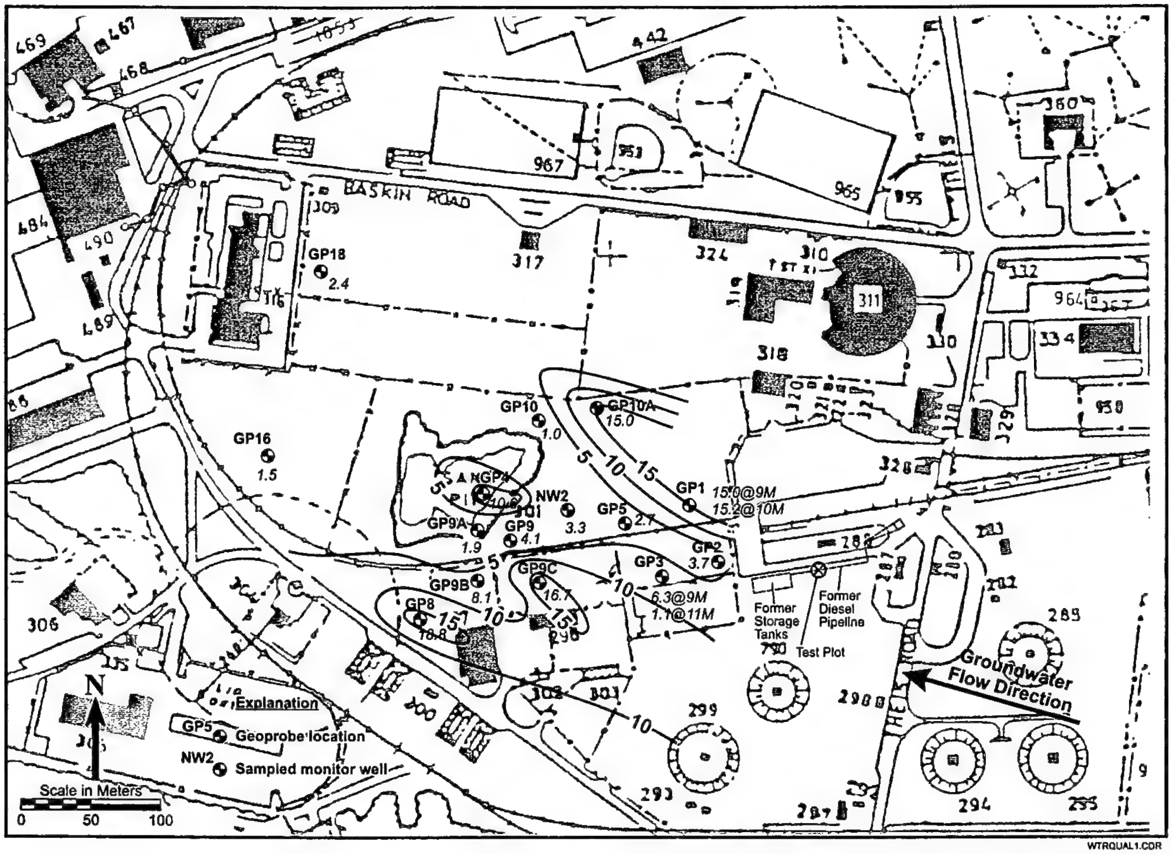


Figure 44a. Nitrate Distribution (mg/L) – 1996

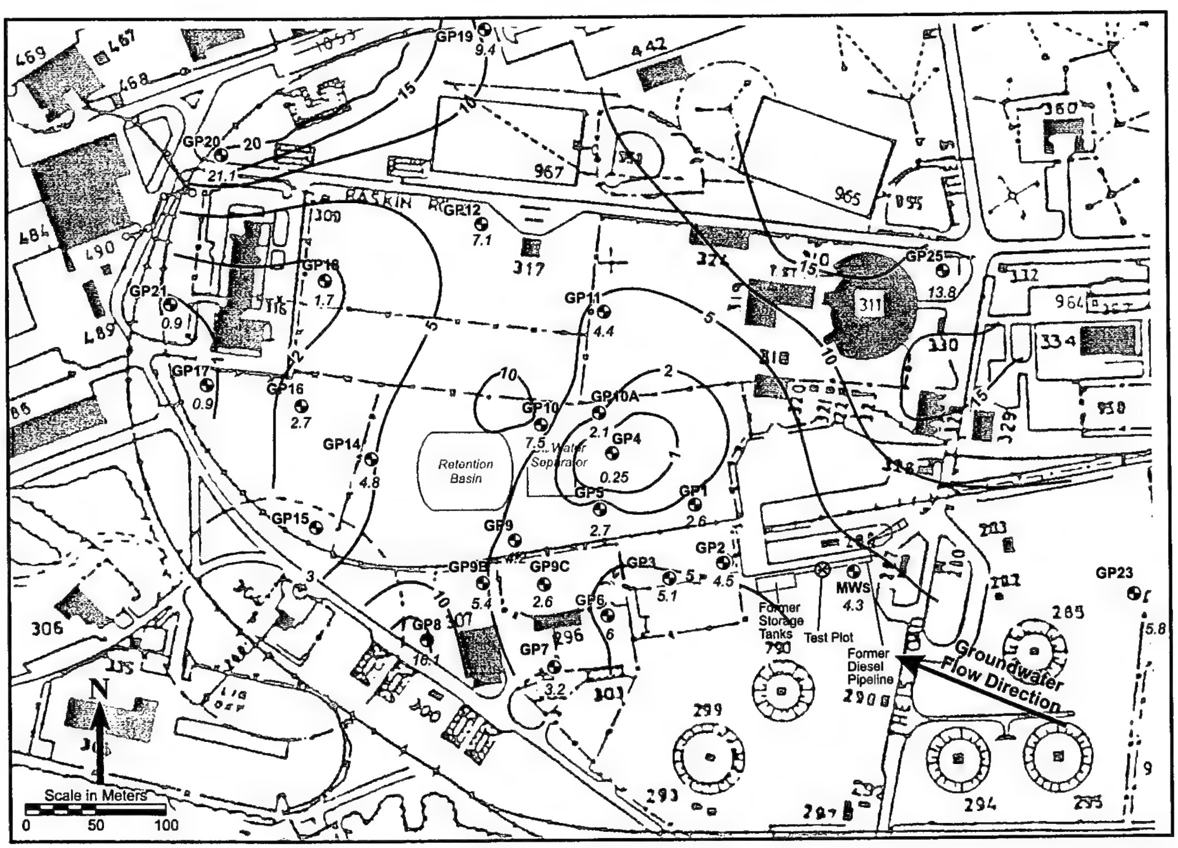


Figure 44b. Nitrate Distribution (mg/L) – 1998

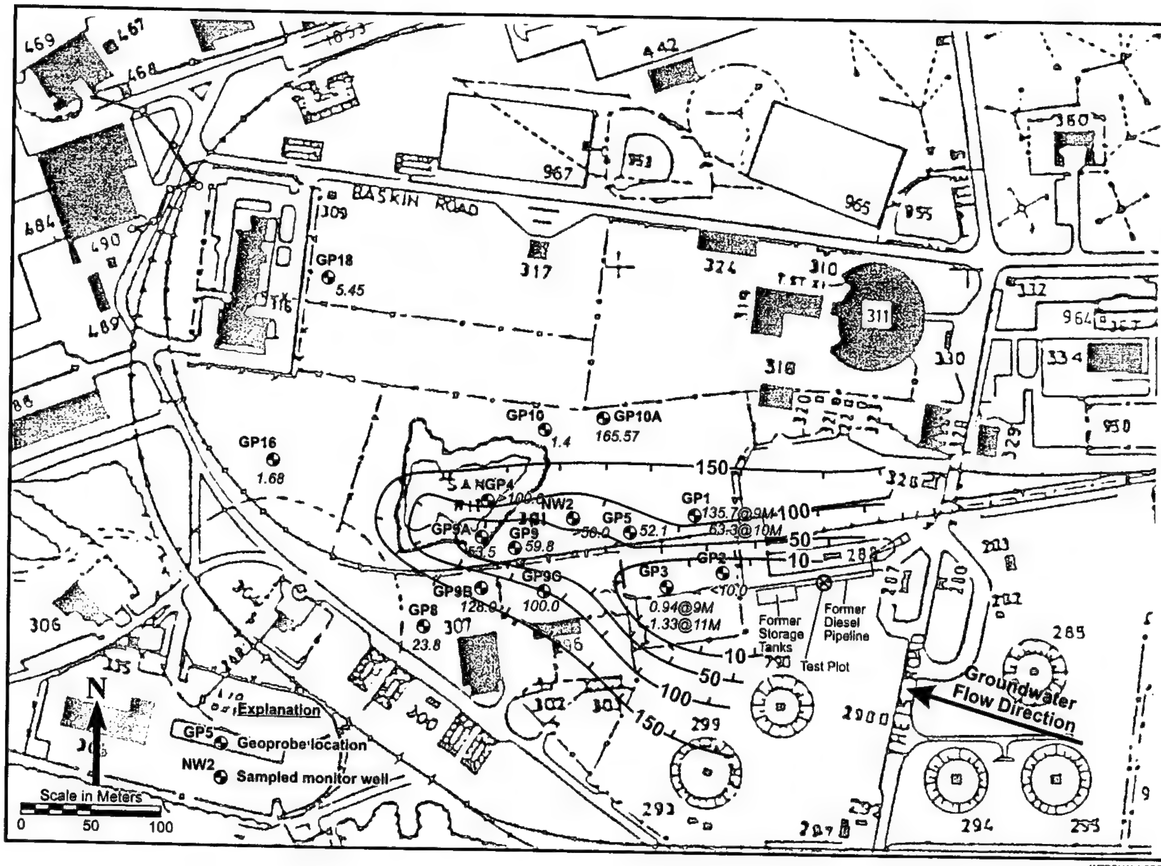


Figure 45a. Sulfate Distribution (mg/L) – 1996

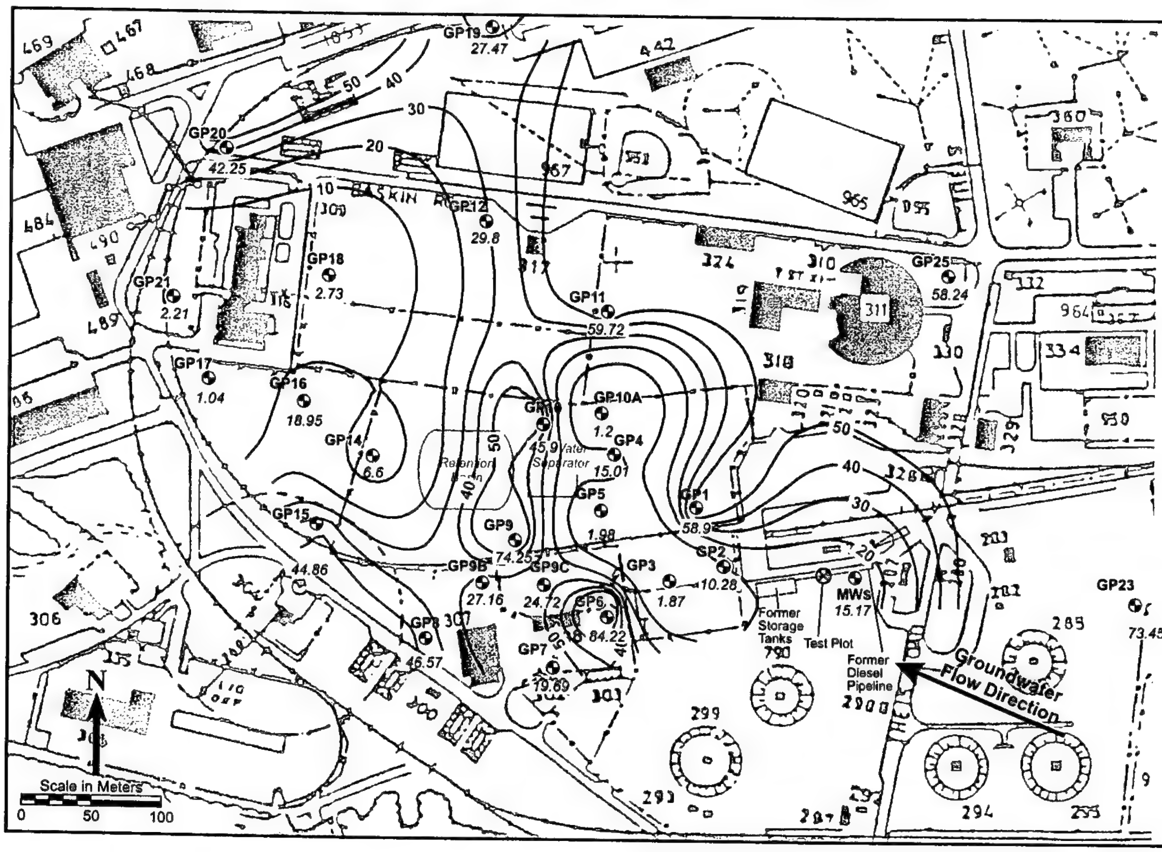


Figure 45b. Sulfate Distribution (mg/L) – 1998

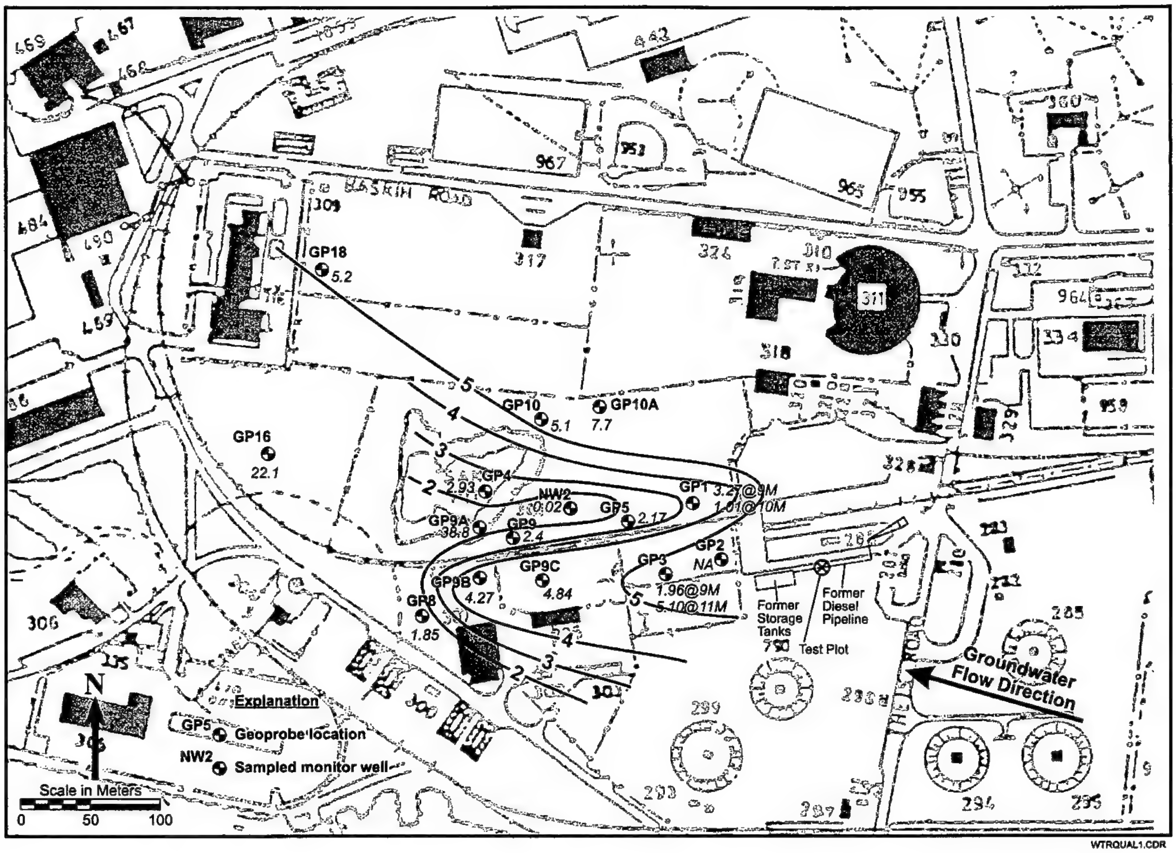


Figure 46a. Iron Distribution (mg/L) – 1996

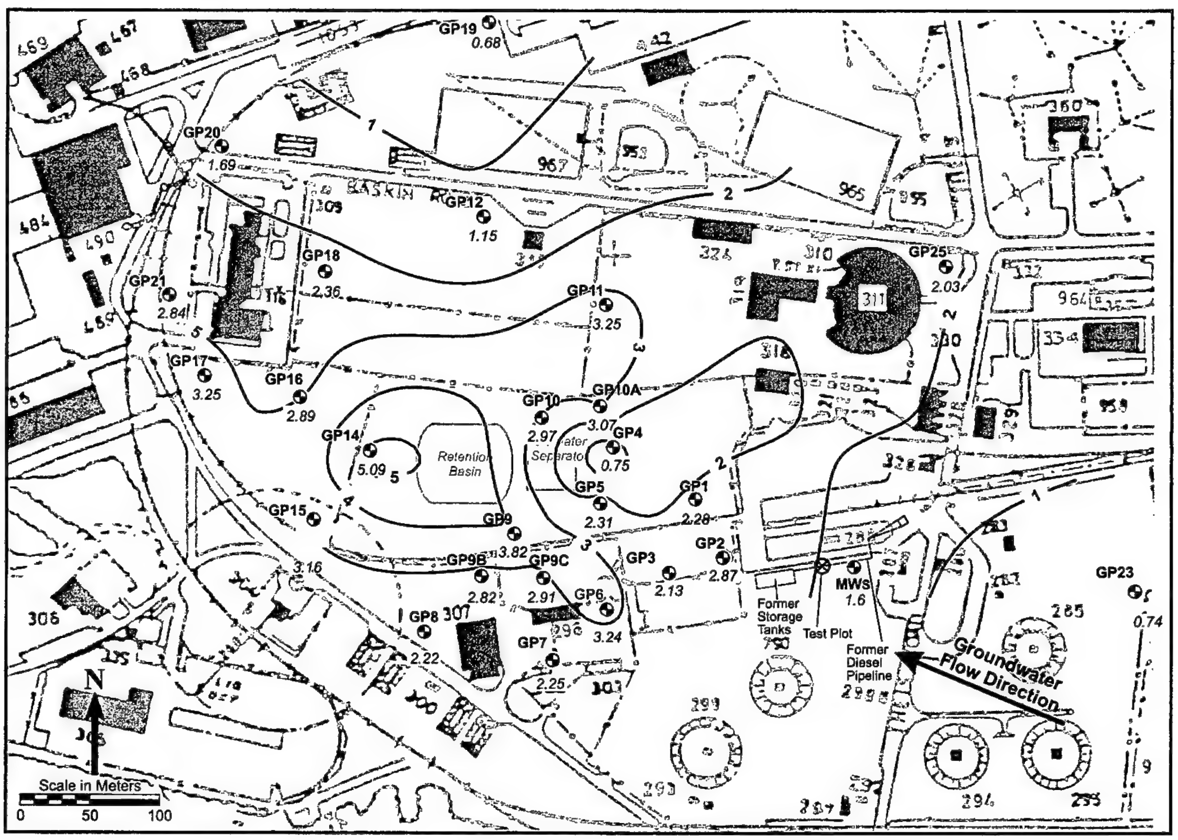


Figure 46b. Iron Distribution (mg/L) – 1998

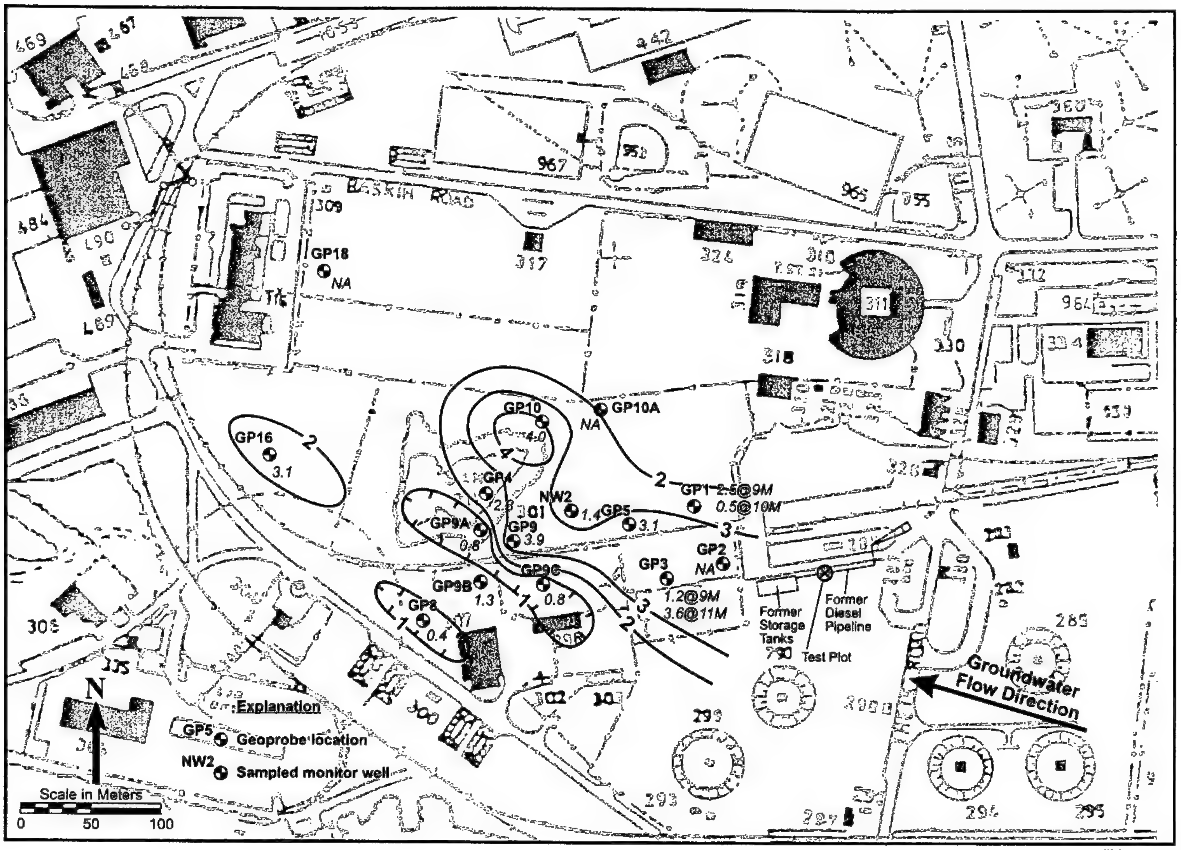


Figure 47a. Manganese Distribution (mg/L) – 1996

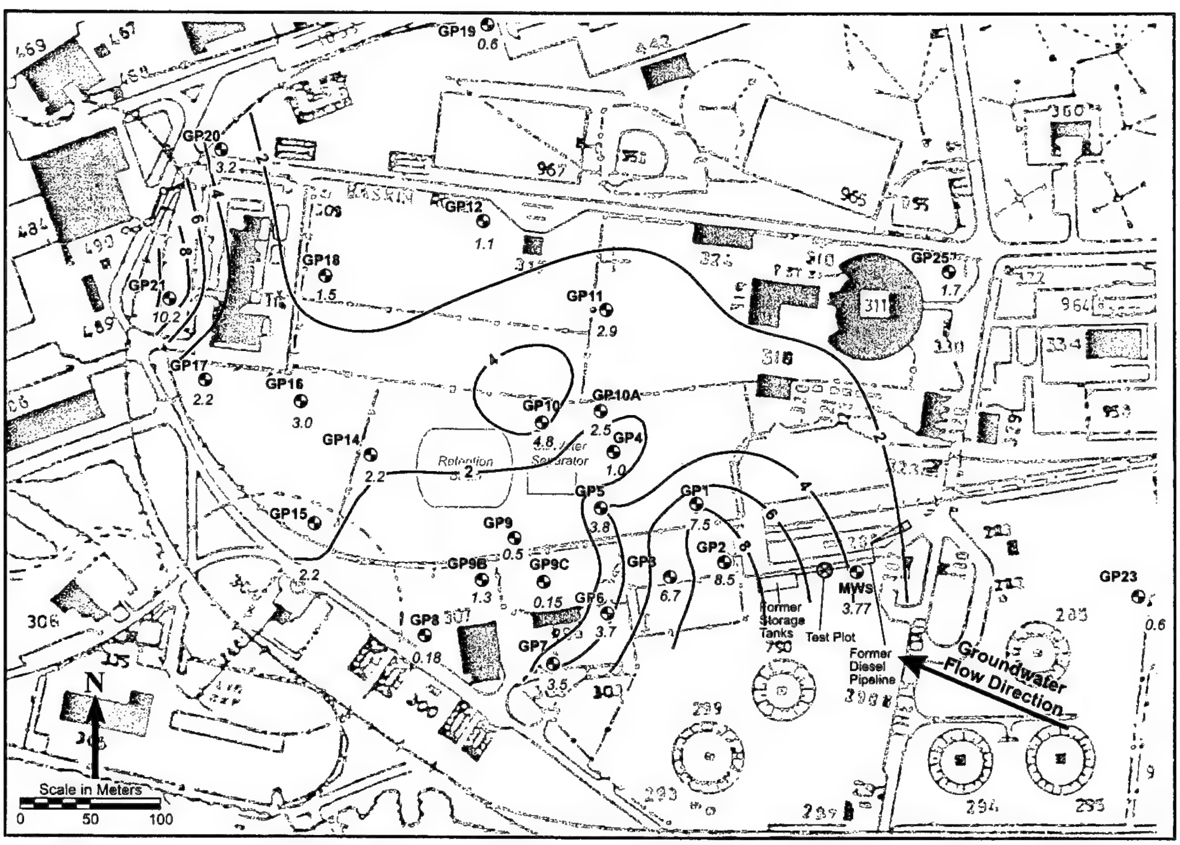


Figure 47b. Manganese Distribution (mg/L) – 1998

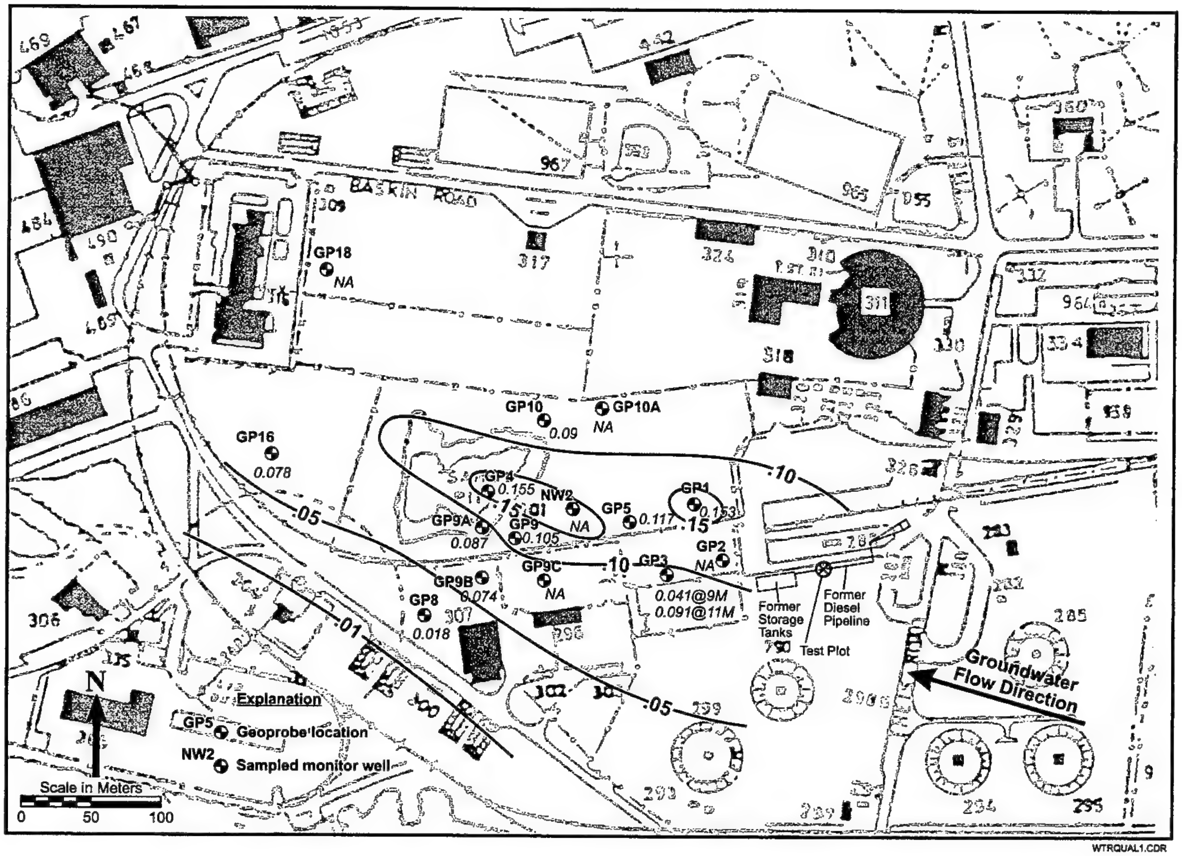


Figure 48a. Sulfide Distribution (mg/L) – 1996

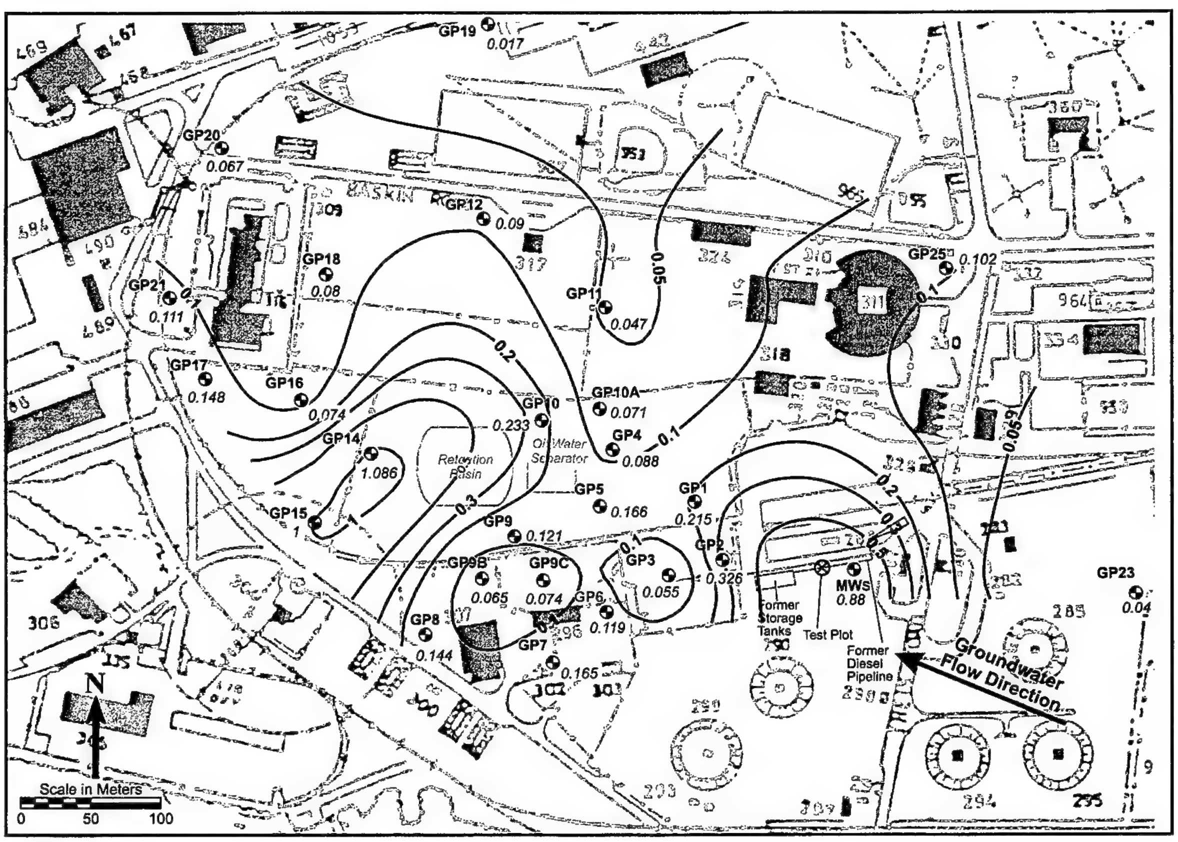


Figure 48b. Sulfide Distribution (mg/L) – 1998

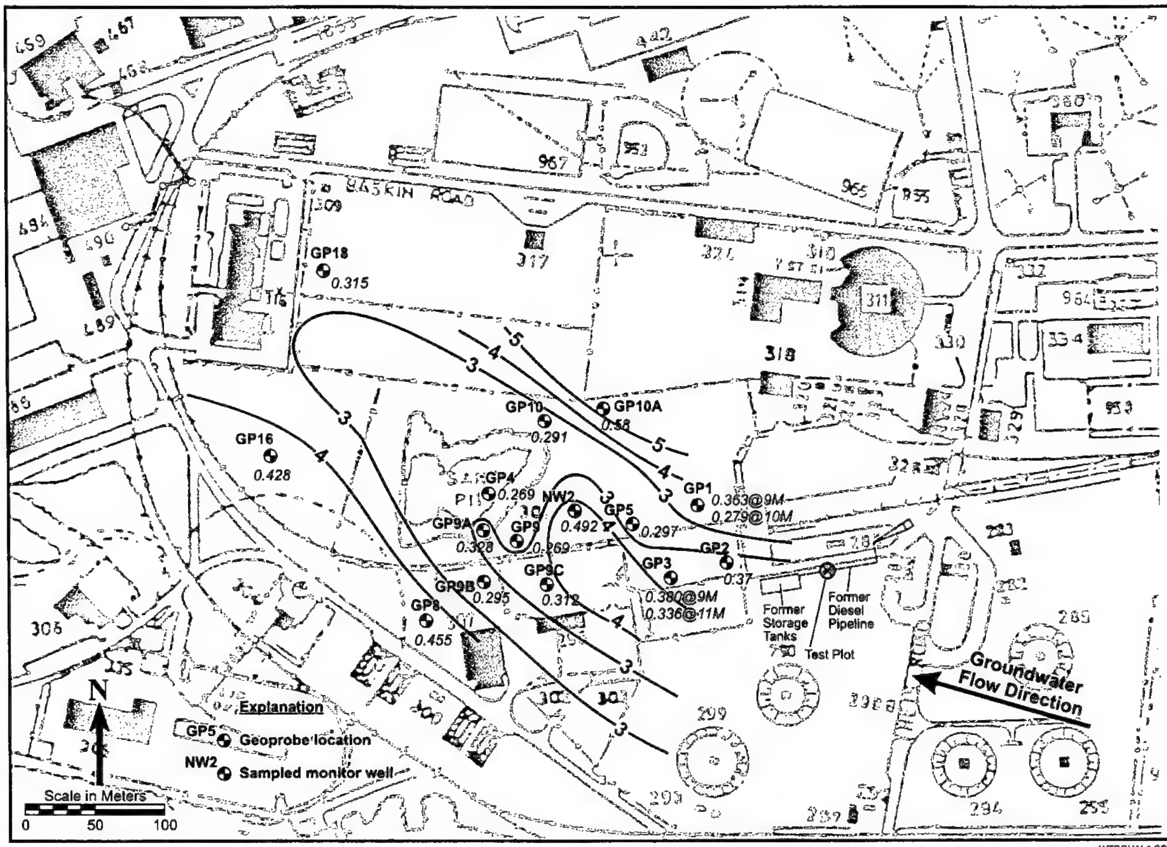


Figure 49a. Conductivity Distribution (mV) – 1996

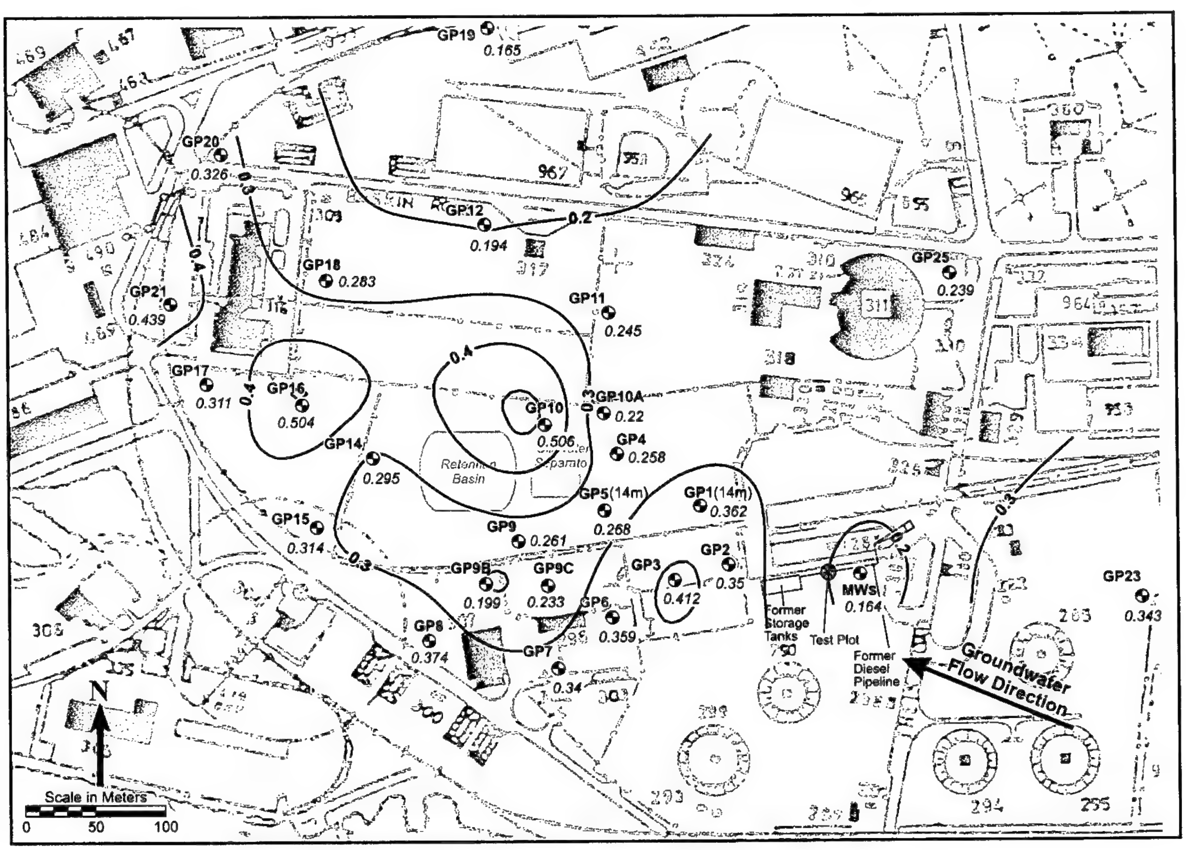


Figure 49b. Conductivity Distribution (mV) – 1998

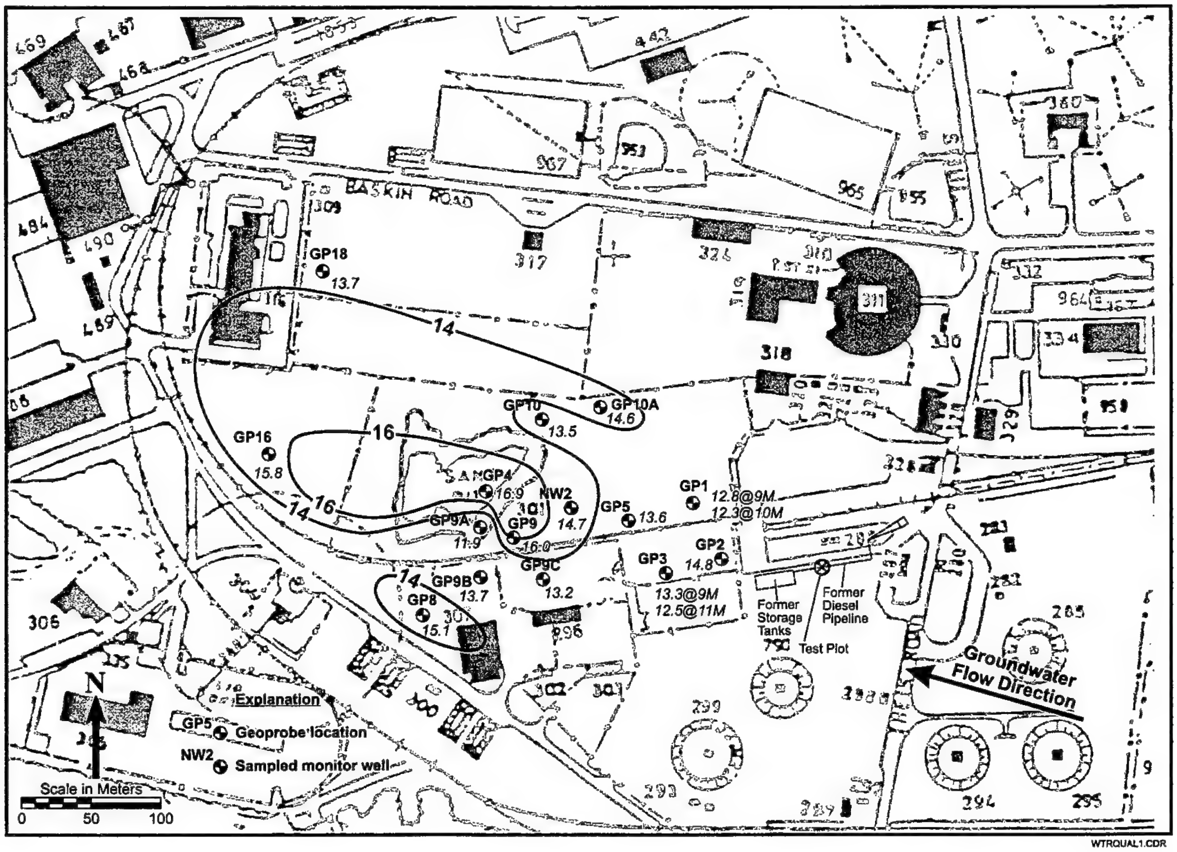


Figure 50a. Temperature Distribution (°C) – 1996

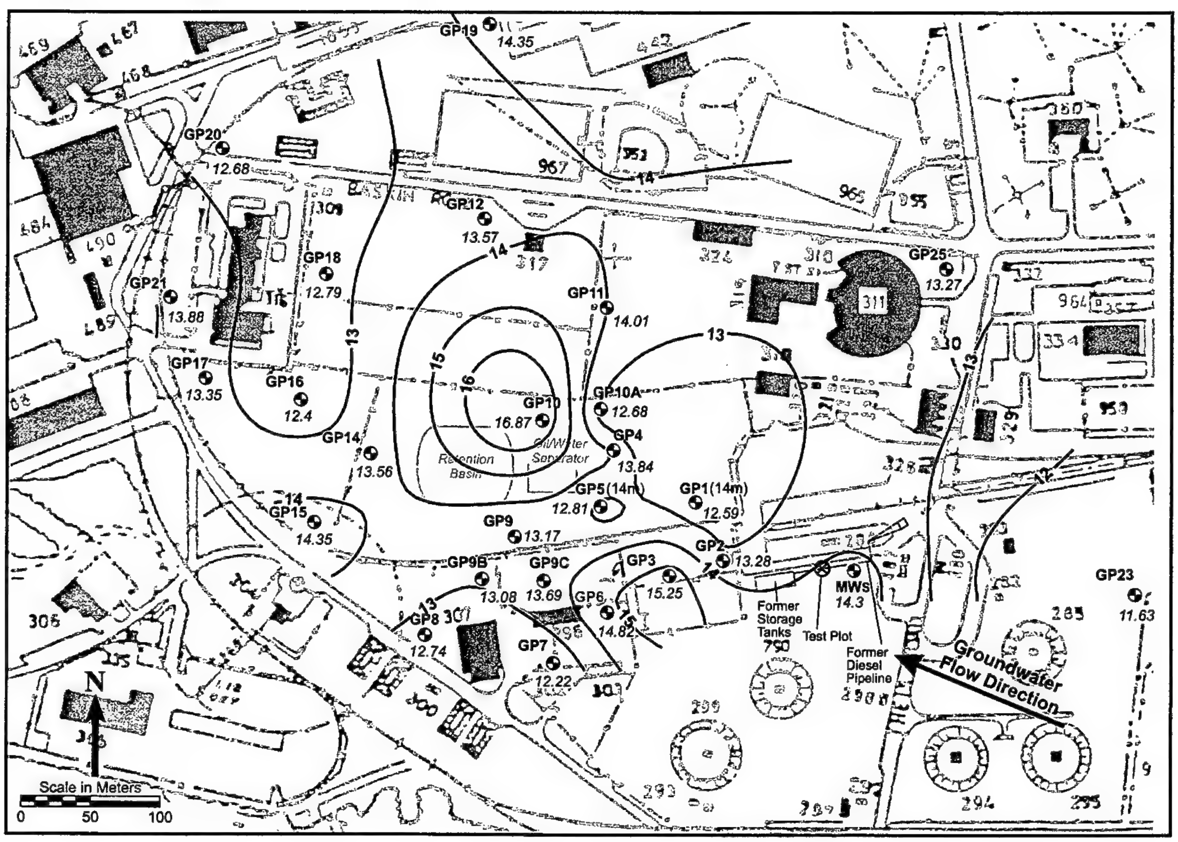


Figure 50b. Temperature Distribution (°C) – 1998

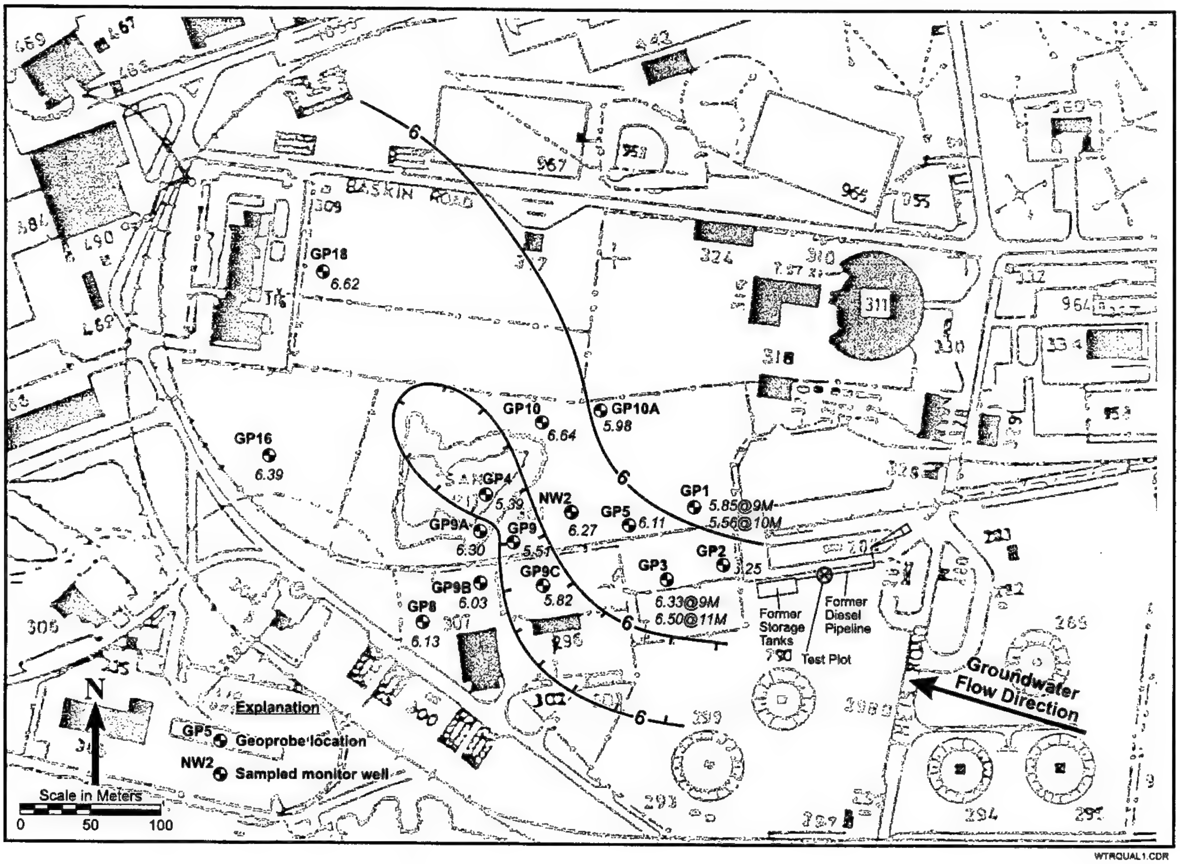


Figure 51a. pH Distribution – 1996

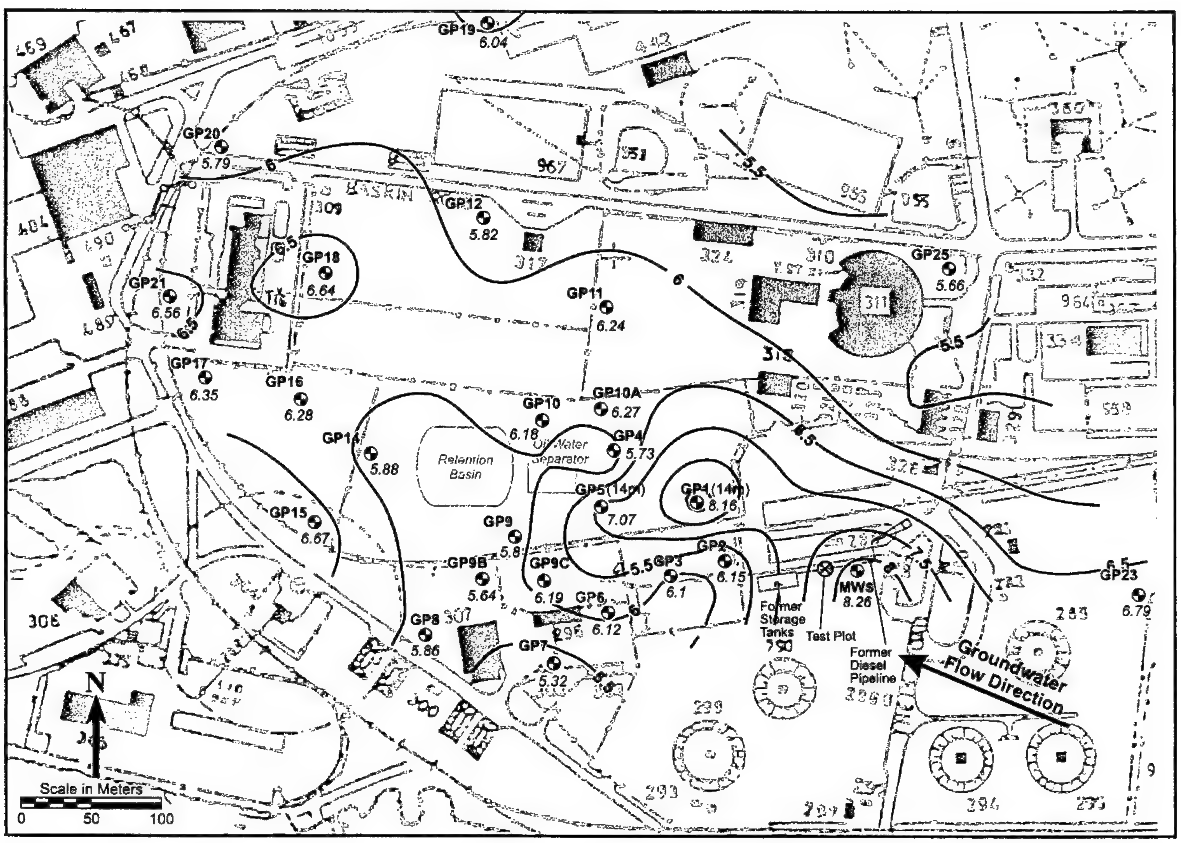


Figure 51b. pH Distribution – 1998

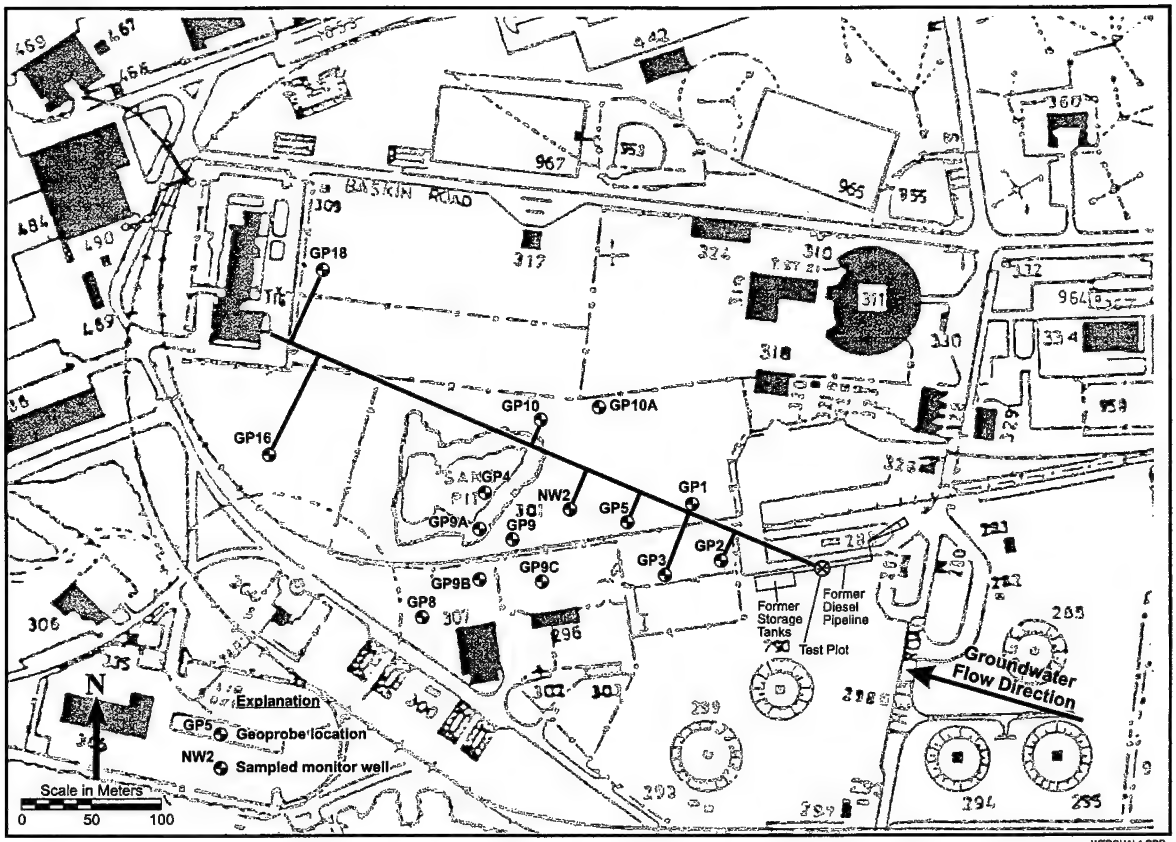


Figure 52. Transect for 1996 (Phase 1) Data Analysis

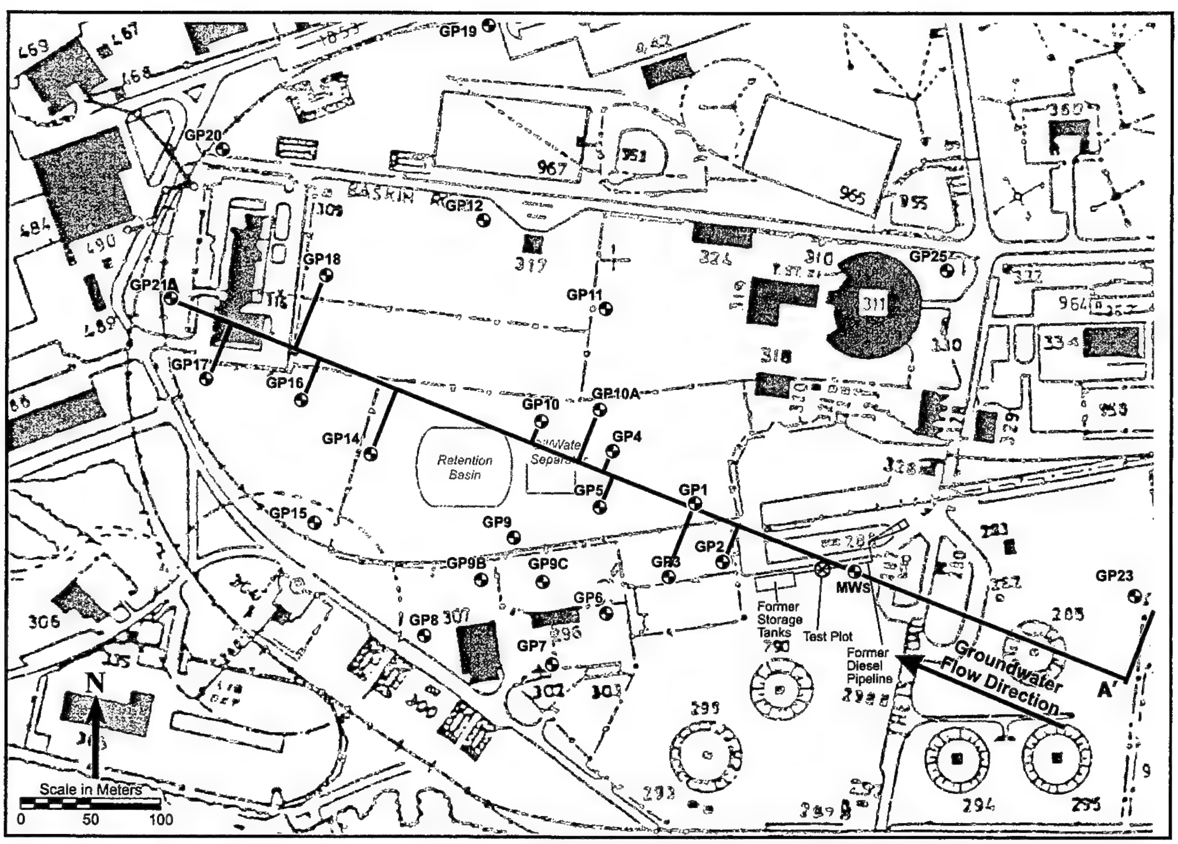


Figure 53. Transect for 1998 (Phase 2) Data Analysis

Trends in these data depicted on the x-y plots can indicate whether the POL Yard source is impacting the concentration of electron acceptors and degradation byproducts in the groundwater. Relationships between these parameters can imply that natural attenuation processes (specifically, intrinsic biodegradation) are working to remediate the plume.

The x-y transect plots are show in Figures 54a and b through 57a and b. The plots present the following analytical results for sample points projected on the transect (1) contaminants (TPH and BTEX); (2) metabolic byproducts (iron and manganese); (3) electron acceptors (nitrate and sulfate); and (4) field parameters (DO, conductivity, Eh, and alkalinity as measured at the probe head). An evaluation of each of these plots, either as support or lack of support for natural attenuation, is presented below.

a. Contaminants: TPH and BTEX Distribution and Attenuation

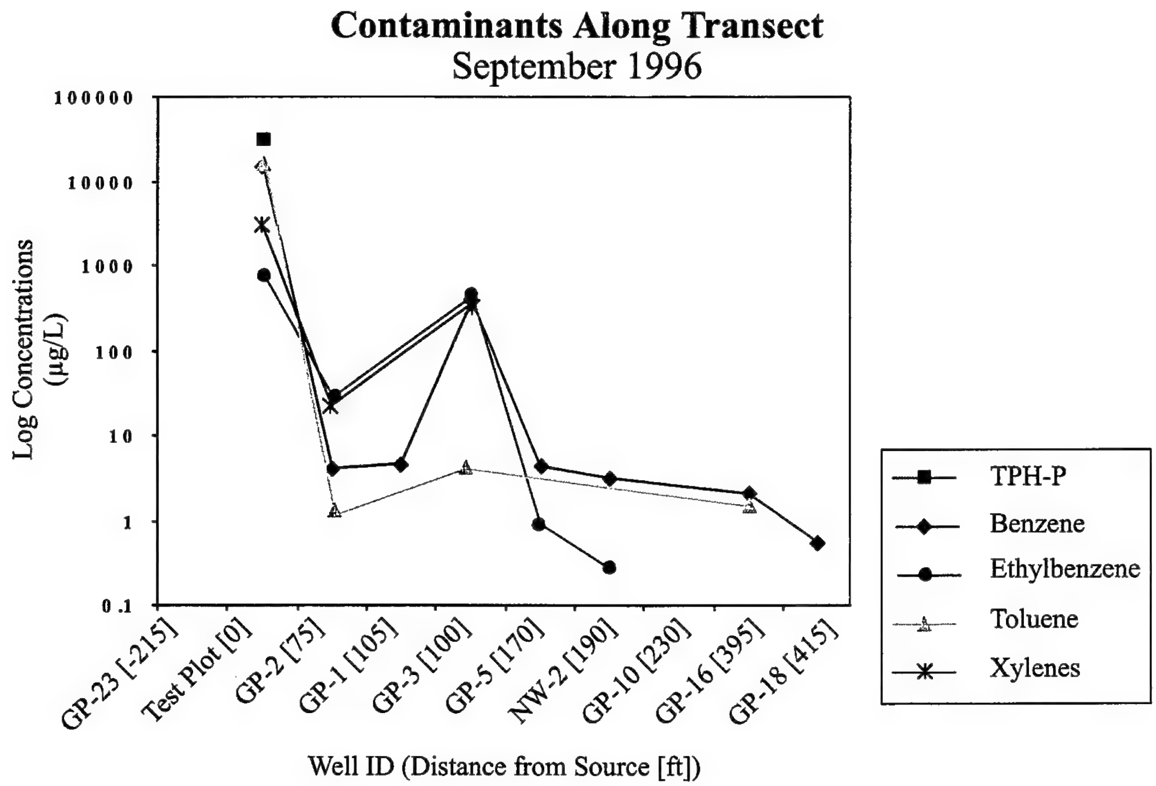
TPH concentrations in groundwater samples reflect the presence of a hydrocarbon plume that originates at the POL Yard and has moved with the groundwater to the northwest. In 1996, during Phase 1, samples were collected from three monitoring wells within the fuel yard and analyzed for TPH and BTEX. Both TPH-extractable and TPH-purgeable analyses were run on these samples to determine if the contaminants were more diesel or gasoline related, and results showed that gasoline phases predominated. Results from the TPH-extractable analysis indicated that components are primarily in the range of gasoline with minor amounts of diesel, light oil, and motor oil. In 1996, TPH-purgeable results from the three POL Yard monitoring wells showed an average and maximum concentration of 35 mg/L and 60 mg/L, respectively. There were no TPH analyses run on any of the GeoProbe® samples in 1996. Because of this, no map has been made to interpret the size and extent of the TPH plume in 1996. It is uncertain how far downgradient TPH components had migrated at that time. It is therefore difficult to determine if the plume is continuing to advance or if it has stabilized.

In 1998, TPH analyses were run on all samples collected from both the POL Yard and GeoProbe® locations. Figure 36 depicts the shape and extent of the TPH plume in 1998. This map indicates that the TPH concentration in the POL Yard average 29 mg/L and that the plume extends to the northwest from the POL yard to at least the area of the GP-10 location, where TPH was detected at 5.9 ppm. Samples from locations farther downgradient show concentrations below the 0.05 mg/L detection limit. A sample collected upgradient of the POL Yard at the GP-23 location was also below the detection limit.

There is also evidence that a lesser amount of TPH exists west of the sand pit, based on results from the GP-14 and GP-16 samples. At these locations TPH measured 0.56 and 0.14 mg/L respectively. It is difficult to determine whether these detections imply that the plume extends this far to the west, or whether the former sand pit may have been the source of this contamination.

The 1998 data indicate that the TPH plume extends some 220 m to the northwest of the POL Yard. Vertical sample profiling performed with the GeoProbe® at the GP-1, GP-3 and GP-5 locations indicate that the most concentrated portion of the plume may be deeper than 10 m bgs at some locations. If true, groundwater samples collected from greater depths might show that the plume is more areal extensive and possibly more concentrated than the existing data portray.

The TPH concentration data imply that the plume may be depleting. The average concentration in the POL Yard dropped from 35 mg/L to 29 mg/L between 1996 and 1998. The



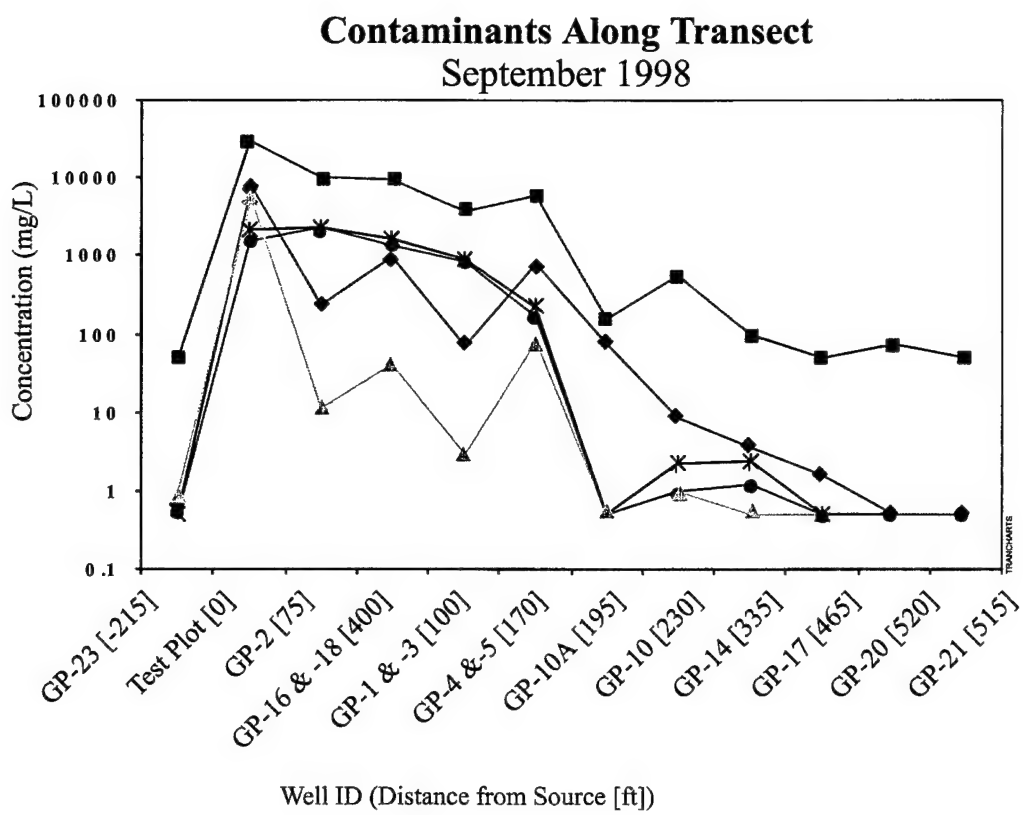
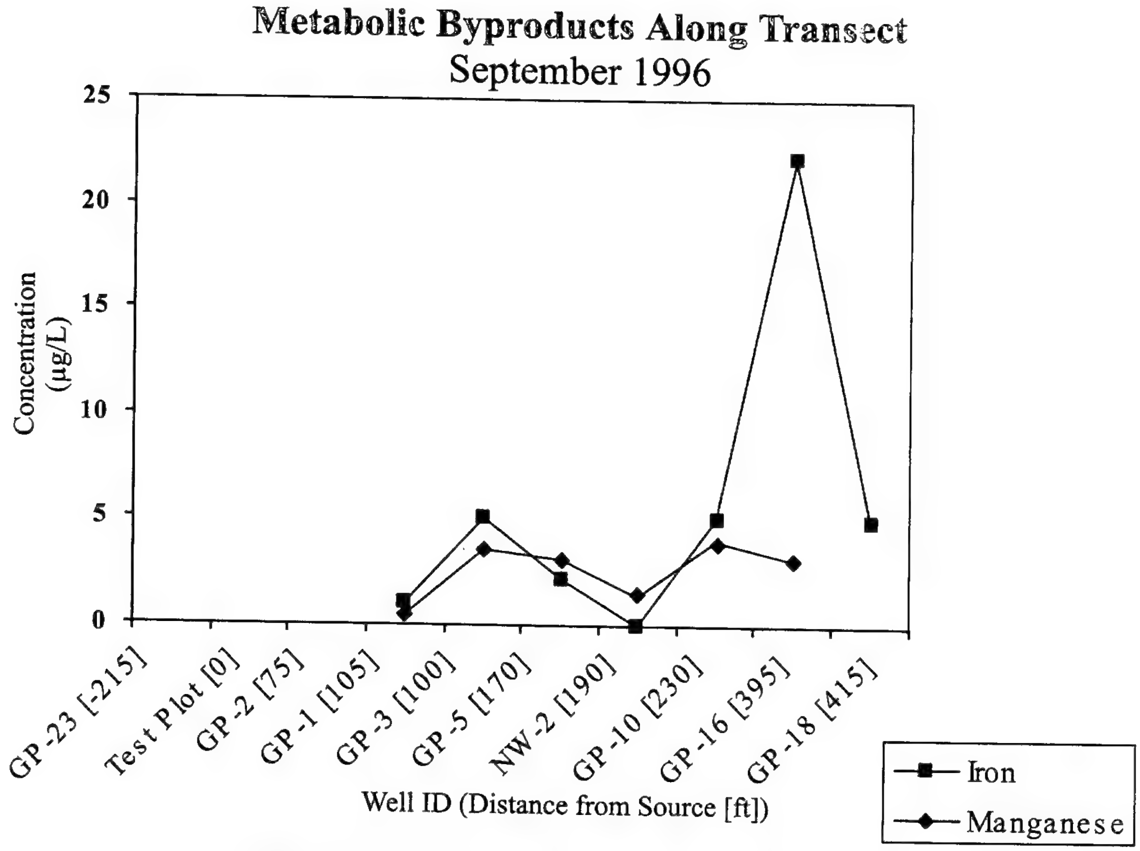


Figure 54. Contaminants Along Transect (a) 1996; (b) 1998



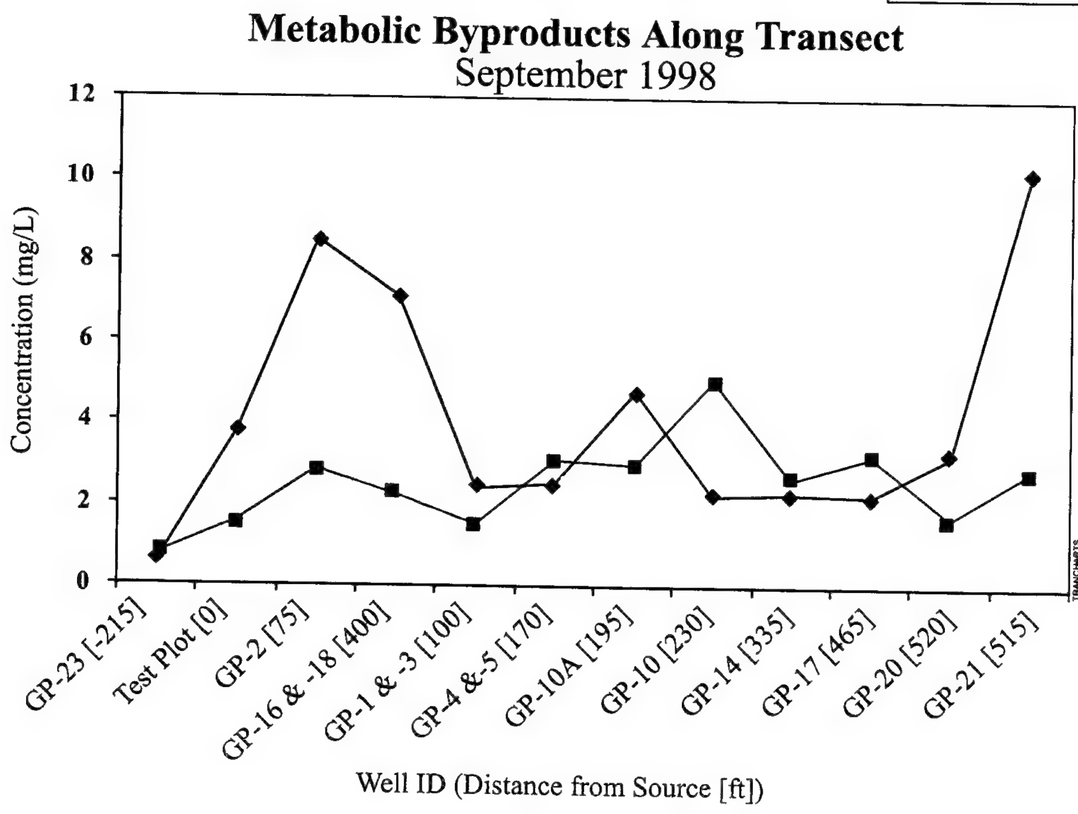
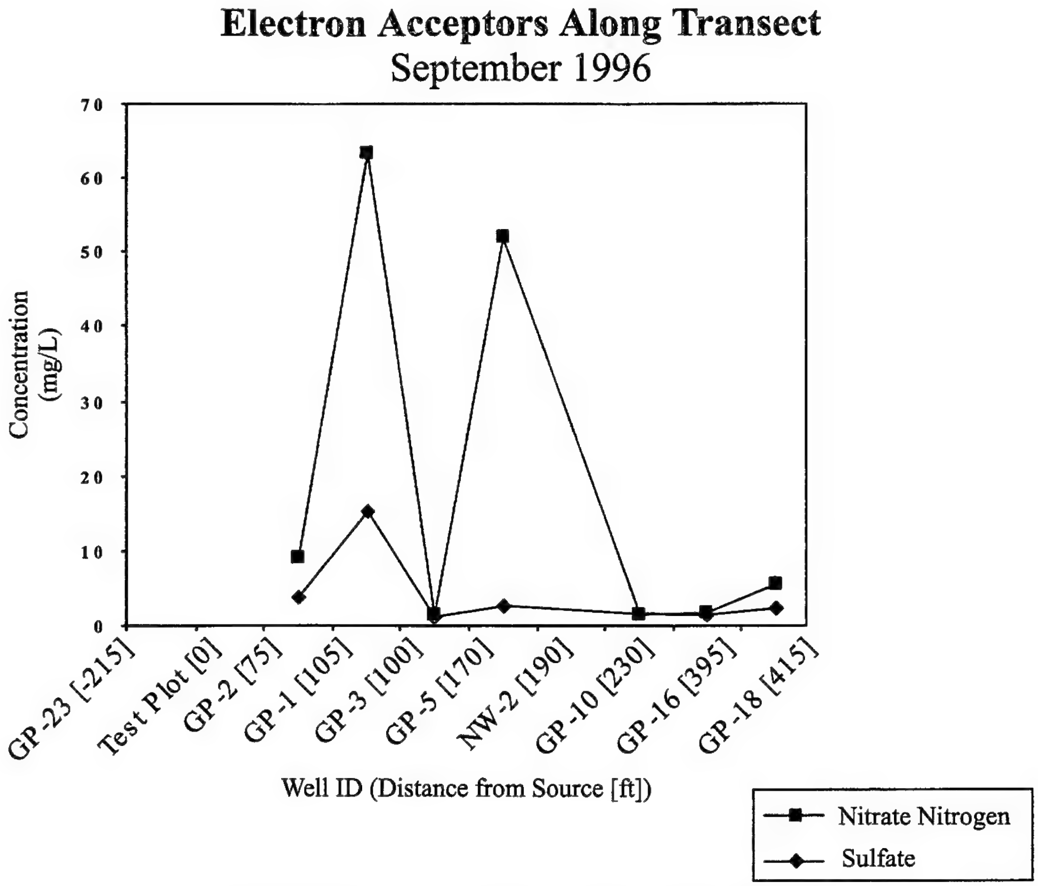


Figure 55. Metabolic Byproducts Along Transect; (a) 1996; (b) 1998



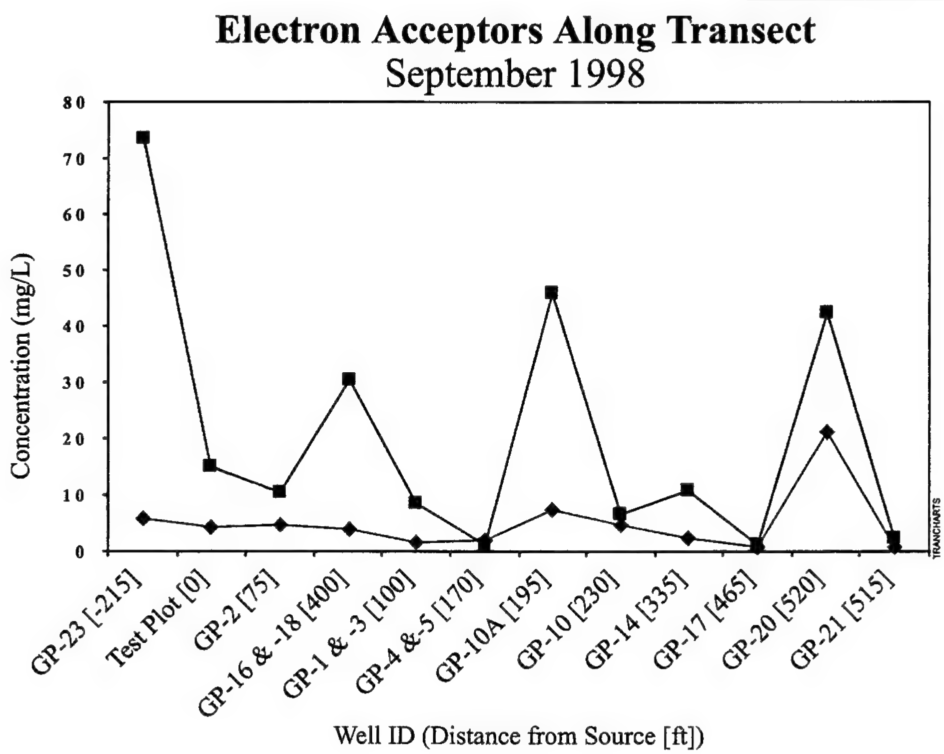


Figure 56. Electron Acceptors Along Transect; (a) 1996; (b) 1998

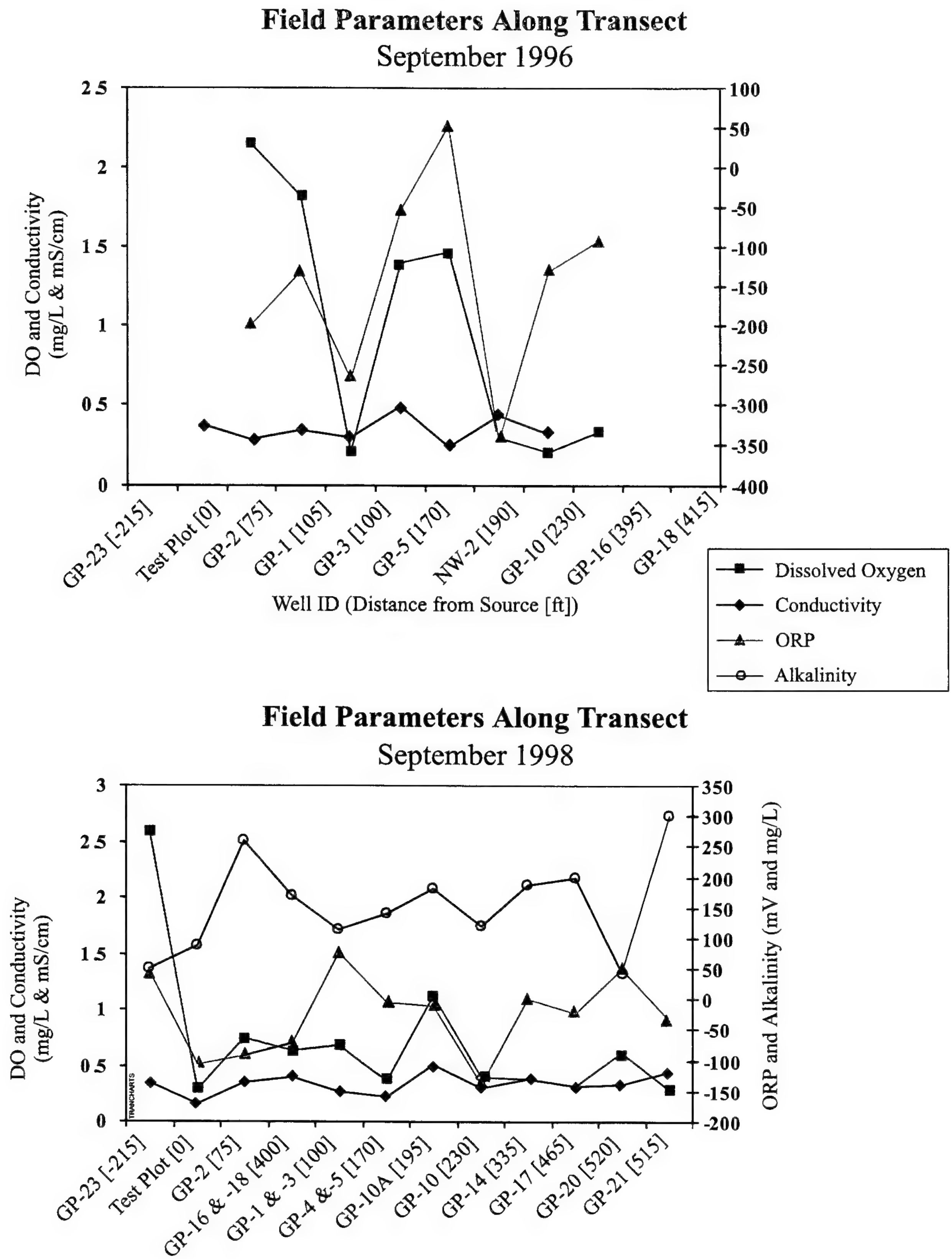


Figure 57. Field Parameters Along Transect; (a) 1996; (b) 1998

maximum concentration dropped from 60 mg/L to 57 mg/L. Results may have been impacted by the active remedial demonstrations in the POL Yard. Additional data are needed to confirm this favorable trend.

BTEX concentrations were measured in 1996 and 1998 in samples collected from both the POL Yard and from all GeoProbe® locations. In 1996, POL Yard benzene and toluene concentrations averaged 15,400 and 13,500 μg/L, respectively. Xylene and ethylbenzene concentrations averaged 2,700 and 787 μg/L, respectively. In 1998, POL Yard benzene and toluene concentrations dropped to averaged levels of 8,467 and 6,093 μg/L, respectively. Xylene and ethylbenzene concentrations in 1998 dropped similarly to averaged levels of 2,170 and 550 μg/L, respectively.

Figure 37b, the map of benzene distribution in 1998 shows a plume that conforms well with the TPH map shown in Figure 36. Significant benzene concentrations (>5 μg/L) are found as far northwest as the GP-10A location. Additional benzene is present west of the sandpit at the GP-14 and GP-16 locations, at concentrations below 10 μg/L. The map in Figure 37b shows that concentrations above the U.S. drinking water standard (5 μg/L) extend at least 330 m northwest from the source. As depicted in Figure 38b, toluene distribution and concentrations are more limited than benzene. This is likely because toluene is more readily biodegraded than benzene (the least biodegradable of the BTEX constituents).

A comparison of Figure 54a with 54b, the transect plots of contaminant concentrations for 1996 and 1998, show the drop in TPH concentration along the plume between the two sampling events. Figure 54b, the 1998 contaminant transect, shows that toluene appears to be depleting more rapidly than benzene, evidence of intrinsic biodegradation.

It is informative to calculate and estimated distance of groundwater flow to determine how far the plume may have migrated. Because the aquifer is predominantly sandy, it is safe to assume that advection would be the primary transport mechanism and that diffusion would not need to be factored into the calculation.

The advective average groundwater velocity (or seepage velocity) is calculated using the following equation (Wiedemeier et al., 1995):

$$v = \frac{K}{n_e}\frac{dH}{dL} \tag{4}$$

where: v = average advective ground water velocity (L/T)
K = hydraulic conductivity (L/T) (2 × 10E-4 M/sec; Freeze and Cheery, 1979)
dH/dL = gradient (dimensionless) (0.0017; Univ. of Fresnuis map)
n_e = effective porosity (%) (30; Freeze and Cherry, 1979)

thus:

$$v = \frac{2\times10^{-4}\text{m/sec} \times 0.00017}{0.30} = 35.7\ \frac{\text{m}}{\text{yr}}$$

It is uncertain when the UST or piping the leak at the POL Yard began. The University of Karlsruhe (Swinianski et al., 1995) reports that the spill was discovered in 1990. Assuming the system was installed in 1950 and that it began to leak in 1970, the leak has been releasing contamination for 28 years to the present (given that the source still exists). If these assumptions are correct, then the distance the plume could be expected to migrate, ignoring the effects of sorption or diffusion, can be calculated using the following equation (5):

$$\begin{aligned} \text{Travel distance} &= v \times \text{time} \\ &= 35.7 \text{ m/yr} \times 28 \text{ yr} \\ &= 999.6 \text{ m} \end{aligned} \tag{5}$$

Assuming that the plume moves at one-third the rate of groundwater flow as a result of retardation, then the plume would have migrated only about 350 meters. This is well within the distance that the survey covered and slightly more than the distance of the existing TPH and BTEX plumes. The fact that the existing plume length is less than the distance the plume should have traveled could point to natural attenuation being responsible for the size of the smaller plume, but more historic and site-specific data and perhaps groundwater flow and transport modeling are need to solidify this claim.

b. Metabolic Byproducts: Iron and Manganese Distribution

Iron and manganese are metabolic byproducts that are produced during the bioremediation of hydrocarbons by iron and manganese reduction. Thus, an increase in the concentration of these byproducts is expected in areas where hydrocarbons are undergoing biodegradation by iron-reducing or manganese-reducing microorganisms.

There is no trend in the 1996 data set that would indicate that either iron or manganese has elevated concentrations in the midst of or immediately downgradient of the source.

However, the 1998 data show some useful evidence of greater concentrations of both of these byproducts in the source area and immediately downgradient of the source. As illustrated in Figure 55b, the transect plot of metabolic byproducts, concentrations in GP-23 for both iron and manganese, are among the lowest levels measured along the transect. Concentrations then increase across the source area and reach the most elevated levels immediately downgradient at the GP-2 location. At GP-2, manganese was measured at its highest concentration along the transect (8.5 mg/L) and iron was measured at 2.87 mg/L. Concentrations in both GP-1 and GP-3 average 7.1 mg/L for manganese and 2.21 mg/L for iron. The values at each of these two locations do not deviate much from this average. However, at a distance of about 170 m, which is the distance of the GP-4 and GP-5 locations, concentrations of both constituents decline, with manganese decreasing more than iron. The concentrations remain generally depressed at greater distances from the source, except for a spike in the concentration of manganese, which elevates to 10.2 mg/L at the GP-21 location. The cause of this elevated reading is unknown.

Figures 47b and 46b are the contour maps depicting distribution of manganese and iron measured in 1998. The plot of manganese shows that there are elevated concentrations immediately downgradient from the source and that the concentration at the source is not the highest recorded

value. There is also a general decline in concentration downgradient from the elevated area, as would be expected in intrinsic biodegradation was impacting the plume. The distribution of iron does not show elevated concentrations near the source.

c. Electron Acceptors: Dissolved Oxygen, Nitrate, and Sulfate Distribution

i. Dissolved Oxygen Distribution. The 1998 data indicate that DO, which is the most thermodynamically favored electron acceptor for fuel biodegradation, is generally depressed across the area of investigation. As illustrated on the 1998 field parameters transect plot (Figure 57b), at the upgradient GP-23 location, DO was measured at a relatively high concentration of 2.58 mg/L. At the crossgradient GP-25 location, which is far outside of the TPH plume, DO was measured at 8.22 mg/L, which is close to fully saturated levels. However, DO levels drop sharply in the POL Yard, where they measured 0.28 mg/L, the lowest value recorded during the survey. DO remains depressed across the remainder of the transect, ranging from 0.74 to 0.32 mg/L, except for an increase to 1.12 mg/L at the GP-10 location. Figure 42b, the contour map of DO concentrations across the survey area in 1998, shows that the plume appears to be having a major impact on DO at all locations that are downgradient of the source. The plume also appears to be impacting locations farther to the west, beyond the former sandpit towards the western boundary of the air base.

The transect plot and map depicting the 1996 data (Figures 57a and 42a) show that DO values do not fit a useful trend. It is appears that several of the early readings made during the first survey were not accurate, specifically, the readings closest to the POL Yard. The abnormally high readings were likely the result of the field geologist not allowing the DO meter to drop to it lowest and most stable level during data collection at those locations. As the field geologist became more adept at using the instrument, DO readings improved when more downgradient readings were collected.

ii. Nitrate and Sulfate Distribution. In addition to DO, nitrate and sulfate were measured and mapped during the surveys. The 1996 sulfate data set is only partially complete and shows values that are highly variable along the transect. The plot lacks a useful, consistent trend. The reading at GP-2 is a relatively depressed 9 mg/L, as would be expected if biodegradation were occurring within and immediately downgradient of the POL Yard source area. But values fluctuate considerably downgradient from the POL Yard as indicated by the measurements at GP-1 of 63.3 mg/L, of 1.33 mg/L at GP-3, and of 52.1 mg/L at GP-5. Figure 45a, which shows the map of 1996 sulfate distribution, appears to be useful in depicting the depletion of this electron acceptor in the immediate vicinity of the source. However the useful trend collapses when values at the most downgradient locations are considered. At GP-16 and GP-18 sulfate was more depleted than at levels immediately adjacent to the POL Yard area. It is not known why this anomaly is present.

The 1998 sulfate data are somewhat more useful, particularly close to the POL Yard. As illustrated in transect plot in Figure 56b, the upgradient sulfate value at GP-23 was measured at 73.45 μg/L. Sulfate is depleted across the POL Yard, measuring 15 mg/L at the Battelle test plot in the POL yard itself and 10.28 mg/L at GP-2. This downward trend continues to the GP-10A location, except for the averaged value for GP-1 and -3. But the value at GP-3 alone is 1.87 mg/L, so perhaps the GP-1 value is erroneous. Downgradient from the GP-1 and -3, sulfate values fluctuate but generally trend downward.

The distribution of nitrate levels measured during both the 1996 and 1998 surveys are generally low at the source, but they are also low upgradient and downgradient of the source. There

are no indications that nitrate is plentiful in the groundwater at the upgradient location. If that is the case, the plume is not utilizing nitrate, so nitrate may not be available to act as an electron acceptor.

d. Other Field Parameters: Oxidation/Reduction Potential, Conductivity, Temperature, and pH Distribution

i. Oxidation/Reduction Eh Potential Distribution. Oxidation/reduction potential (Eh) is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. Eh values typically range from -400 mV to 800 mV in groundwater. At any location in a plume, more negative readings reflect more anaerobic or reducing conditions. The general range of aerobic and reducing conditions, measured as Eh are as follows: aerobic (+800 to +500 mV); nitrate reducing (+500 to +200 mV); iron reducing (+200 to -100 mV); manganese reducing (100 to -250 mV); sulfate reducing (-250 to -400 mV); and methanogenic (less than -400 mV). The rate of electron transfer, which is directly related to the rate of biodegradation of petroleum hydrocarbons, happens most readily in aerobic conditions and gradually decreases until the lowest rates are experienced under methanogenic conditions.

As shown in Figure 57a, the 1996 Eh readings along the transect show depressed values immediately downgradient of the source at the GP-2 location (-201 mV). Farther downgradient, Eh readings fluctuate, but remain depressed until the GP-5 and NW-2 locations, where it rises sharply to values of -55 mV and +53 mV, respectively.

The 1998 data set shows trends that are similar to the 1996 data. Eh was measured at +43.4 mV at the upgradient GP-23 location, but drops sharply across the POL Yard area where the lowest value is recorded (-108 mV). Downgradient from the Yard, Eh values stay depressed for about 100 m before rising sharply at the GP-4 and GP-5 locations, where it was measured at an average value of +76.3 mV. Farther downgradient, the Eh values fluctuate but remain generally negative. The map depicting the distribution of Eh readings collected in 1998 shows depressed, generally negative readings downgradient across the area of the plume. Readings are much more positive in upgradient and cross-gradient areas. The cause of the positive anomaly at the GP-4 location is not known, but the reading is thought to be accurate.

ii. Conductivity, Temperature, and pH Distribution. Conductivity, temperature, and pH do not appear to be clearly influenced by the source or the plume. Conductivity values trend lower and then higher with increased distance downgradient from the source. Temperature appears to be much more influenced by the sand pit than by the plume. The distribution of pH does not seem to fit any trend associated with the plume, and the range of pH values is narrow (from 5.39 to 6.62).

2. Conceptual Model of Contamination and Natural Attenuation

The Geoprobe®-based groundwater sampling and analysis performed downgradient of the known fuel leak in the POL Yard indicate that a dissolved-phase plume has been created in the water table aquifer. This plume contains TPH and BTEX constituents that have moved in the direction of groundwater flow (northwest) toward the Base boundary. Sampling and analysis indicates that TPH is present at concentrations has high as 1 mg/L at least 220 m northwest of the POL Yard, and benzene is present at concentrations as high as 5 μg/L at least 330 m northwest of the POL Yard. The vertical extent of the plume has not been fully defined.

The limited amount of data collected during two field surveys — the spatial distributions of contamination, degradation byproducts, electron acceptors, and relevant field parameters — generally indicate that intrinsic biodegradation is taking place within the plume. The trends of key parameters, especially across the source area from the upgradient to the first of the downgradient sampling locations, reflect conditions that are present when a hydrocarbon plume is undergoing intrinsic biodegradation, the most significant natural process.

Many of the key parameters are distributed erratically. This can be attributed to aquifer heterogeneity (both laterally and vertically within the aquifer), the presence of other potential downgradient sources, and operator and instrument error during the data collection and analysis.

The conclusion that natural attenuation is occuring is most strongly supported by the distribution and spatial trend of contaminant constituents, electron acceptors, and degradation products upgradient and immediately downgradient of the source. DO data show that aerobic conditions are clearly present upgradient from the source, and that the aquifer becomes far less rich in oxygen under the POL Yard. The aquifer remains relatively low in oxygen at most downgradient locations where measurements were collected. There is clearly a reduction of electron acceptors under the POL Yard and at location GP-2, the first downgradient location. Conversely, metabolic byproducts are increasing from the upgradient location, across the POL Yard, downgradient to the location GP-1. Together, these trends suggesst that intrinsic biodegradation processes are acting on the hydrocarbon contaminants in the groundwater.

D. CONCLUSIONS AND RECOMMENDATIONS

The collection of a more extensive data set is needed to determine which specific biodegradation processes are present at this site, and to then calculate the rate of degradation. This data set should include the following:

- **Better characterization of the hydrocarbon plume.** Specifically, greater knowledge of the distribution of TPH and BTEX is needed. More meaningful conclusions can be drawn from concentrations of electron acceptors and degradation products if the plume distribution is better known. Additional vertical and lateral sampling should be performed at both existing and at new locations. It would also be helpful to learn more about the history of the spill.

- **Verification of the water quality parameter measurements.** To date, the results from the Hach® kits and GC have not been verified by independent laboratory analyses. Some of the data collected by the YSI instruments were verified by using another instrument that was available in the field, but that verification was not rigorous. Verification of all instrument-derived data would increase confidence in the results and conclusions.

- **Collection of additional background data.** It would be very useful to collect background data at more than one location. These data would provide greater insight into ambient concentration for the various water quality parameters, and should be collected at locations that are upgradient and outside of the POL Yard.

- **Develop and implement a groundwater monitoring plan.** Once the plume has been fully delineated, a monitoring program should be planned and implemented to chart the progress of plume reduction and the trend of the relevant natural attenuation parameters. This plan should be presented to all stakeholders (local citizens, government regulators, and Base officials) to gain approval to implement a monitoring program that lasts at least two years, consisting of sample collection on a quarterly basis. A more extensive data set needs to present convincing and defendable evidence of natural attenuation.

- **Development of a numerical model.** This model would (1) represent all known site conditions, and (2) simulate and predict the rate of natural attenuation and its impact on the plume and overall groundwater quality with the progression of time.

SECTION V
REFERENCES

Downey, D.C. and J.F. Hall. 1994. Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural Attenuation Potential. U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, TX.

Dupont, R.R. 1987. "A Sampling System for the Detection of Specific Hazardous Constituent Emissions from Soil Systems." In: *Hazardous Waste: Detection, Control, Treatment*, pp. 581-592, Amsterdam, The Netherlands, Elsevier Science Publisher, B.V.

Dupont, R.R., W.J. Doucette, and R.E. Hinchee. 1991. "Assessment of In Situ Bioremediation Potential and the Application of Bioventing at a Fuel-Contaminated Site." In R.E. Hinchee and R.F. Olfenbuttel (Eds.), *In Situ Bioreclamation: Applications and Investigations for Hydrocarbon and Contaminated Site Remediation*, pp. 262-282. Butterworth-Heinemann, Stoneham, MA.

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater*. Prentice-Hall, Inc., Englewood Cliffs, NJ.

Hessiches Landesamt für Bodenforschung. 1980. Geologische Karte von Hessen 1:25000 Erlauterungen 5917 Kelsterbach, Wiesbaden, Germany, 221 pp.

Hinchee, R.E. and S.K. Ong. 1992. "A Rapid In Situ Respiration Test for Measuring Aerobic Biodegradation Rates of Hydrocarbons in Soil." *Journal of the Air & Waste Management Association*, *42*(10): 1305-1312.

Institut Fresenius. 1994. Flughafen Frankfurt/Main Grundwasserguteuberwachung Grundwasserfleichenplan 17-18 Okt. 1994.

Leeson, A. and R.E. Hinchee. 1996. *Soil Bioventing: Principles and Practice*. CRC Press, Boca Raton, FL.

McVeety, B.D. 1991. *Current and Developing Analytical Technologies for Quantifying Biogenic Gas Emissions*. Report on Contract 600/3-91/044 from Pacific Northwest Laboratory to U.S. Environmental Protection Agency, Corvallis, OR, NTIS Report #PB91-216523, June.

Miller, R.N., C.C. Vogel, and R.E. Hinchee. 1991. "A Field-Scale Investigation of Petroleum Hydrocarbon Biodegradation in the Vadose Zone Enhanced by Soil Venting at Tyndall AFB, Florida." In R.E. Hinchee and R.F. Olfenbuttel (Eds.), *In Situ Bioreclamation: Applications and Investigations for Hydrocarbon and Contaminated Site Remediation*, pp. 283-302, Butterworth-Heinemann, Stoneham, MA.

Swinianski, I. J., H. Wurdemann, F. Gleisner, G.N. Pralle, I.A. Einhardt, and I.G. Gudehus. 1995. *Field Demonstration of In-Situ Bioremediation at the Rhein-Main Air Base in Frankfurt*. First Report. Contractor Number: E/T 31 A/Q 0063/F 5138. Lehrstuhl Fur Bodenmechanik und Grundbau (IBF), Universitat (TH) Fridericiana Karlsruhe.

Wiedemeier, T.H., J.T. Wilson, D.H. Kampbell, R.N. Miller, and J.E. Hansen. 1995. *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater*. Report prepared for the U.S. Air Force Center for Environmental Excellence, Technology Transfer Division, Brooks Air Force Base, San Antonio, TX.

APPENDIX A

LABORATORY ANALYTICAL RESULTS

WORK ORDER #: 9605077

Work Order Summary

CLIENT: Mr. Greg Headington
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201-2693

BILL TO: Same

PHONE: 614-424-4996
FAX: 614-424-3667
DATE RECEIVED: 5/8/96
DATE COMPLETED:

INVOICE #
P.O. # 114865
PROJECT # Rhein-Main AB
AMOUNT$: $665.02

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	MPD-RED	TO-3	0 "Hg	$120.00
02A	MPC-RED	TO-3	0 "Hg	$120.00
03A	MPA-RED	TO-3	0 "Hg	$120.00
04A	MPB-BLACK	TO-3	0 "Hg	$120.00
05A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter Summa Canister Preparation (4) @ $15.00 each.	$60.00
	Shipping (4/15/96)	$125.02

PRELIMINARY

CERTIFIED BY: Debbie Pearcefor
Laboratory Director

DATE: 5-13-96

AIR TOXICS LTD.

SAMPLE NAME: MPD-RED
ID#: 9605077-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6050913		Date of Collection: 5/6/96	
Dil. Factor:	2.02		Date of Analysis: 5/9/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.002	0.007	Not Detected	Not Detected
Toluene	0.002	0.008	Not Detected	Not Detected
Ethyl Benzene	0.002	0.009	Not Detected	Not Detected
Total Xylenes	0.002	0.009	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	6050913		Date of Collection: 5/6/96	
Dil. Factor:	2.02		Date of Analysis: 5/9/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.020	0.13	0.40	2.6
C2 - C4** Hydrocarbons	0.020	0.037	0.027	0.049

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: MPC-RED

ID#: 9605077-02A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6050914 | Date of Collection: 5/6/96

Dil. Factor: 25.2 | Date of Analysis: 5/9/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.025	0.082	0.98	3.2
Toluene	0.025	0.097	1.1	4.2
Ethyl Benzene	0.025	0.11	3.9	17
Total Xylenes	0.025	0.11	14	62

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name: 6050914 | Date of Collection: 5/6/96

Dil. Factor: 25.2 | Date of Analysis: 5/9/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.25	1.6	220	1400
C2 - C4** Hydrocarbons	0.25	0.46	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: MPA-RED

ID#: 9605077-03A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6050915		Date of Collection: 5/6/96	
Dil. Factor:	101		Date of Analysis: 5/9/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.10	0.33	7.5	24
Toluene	0.10	0.39	7.0	27
Ethyl Benzene	0.10	0.45	13	57
Total Xylenes	0.10	0.45	32 M	140 M

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6050915		Date of Collection: 5/6/96	
Dil. Factor:	101		Date of Analysis: 5/9/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	1.0	6.5	4600	30000
C2 - C4** Hydrocarbons	1.0	1.8	1.3	2.4

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

M = Reported value may be biased due to apparent matrix interferences.

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: MPB-BLACK
ID#: 9605077-04A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6050916			Date of Collection: 5/6/96	
Dil. Factor: 101			Date of Analysis: 5/9/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.10	0.33	25	81
Toluene	0.10	0.39	16	61
Ethyl Benzene	0.10	0.45	11	48
Total Xylenes	0.10	0.45	25	110

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6050916			Date of Collection: 5/6/96	
Dil. Factor: 101			Date of Analysis: 5/9/96	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	1.0	6.5	8000	52000
C2 - C4** Hydrocarbons	1.0	1.8	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9605077-05A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6050904 Date of Collection: NA
Dil. Factor: 1.00 Date of Analysis: 5/9/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6050904 Date of Collection: NA
Dil. Factor: 1.00 Date of Analysis: 5/9/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 04/01/96 Received: 04/03/96 Analyzed: 04/07-08/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
RM1-VW3-1.5-2.0 /BMI040396-01	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-2.5-3.0 /BMI040396-02	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-3.5-4.0 /BMI040396-03	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-4.5-5.0 /BMI040396-04	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
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FAX: 702-355-0406
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e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

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Las Vegas, Nevada 89120
(702) 498-3312
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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
RM1-VW3-5.5-6.0 /BMI040396-05	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-6.5-7.0 /BMI040396-06	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-7.5-8.0 /BMI040396-07	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-8.5-9.0 /BMI040396-08	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-9.0-9.5 /BMI040396-09	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-10.0-10.5 /BMI040396-10	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW3-11.0-11.5 /BMI040396-11	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW3-12.0-12.5 /BMI040396-12	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-13.0-13.5 /BMI040396-13	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-14.0-14.5 /BMI040396-14	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-15.5-16.0 /BMI040396-15	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-16.5-17.0 /BMI040396-16	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-17.0-17.5 /BMI040396-17	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-18.0-18.5 /BMI040396-18	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW3-23.5-24.0 /BMI040396-19	TPH (Purgeable)	150	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-24-24.5 /BMI040396-20	TPH (Purgeable)	41	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-26-26.5 /BMI040396-21	TPH (Purgeable)	39	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-26.5-27 /BMI040396-22	TPH (Purgeable)	280	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	170	100	ug/Kg
	Ethylbenzene	120	100	ug/Kg
	Total Xylenes	340	100	ug/Kg
RM1-VW3-27.5-28 /BMI040396-23	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	98	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW3-28-28.5 /BMI040396-24	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	140	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 4/18/96
Roger L. Scholl, Ph.D.
Laboratory Director

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. Page 1 of 2

Proj. No. G002737-01

Project Title: Rhein-Main Air Base POL Yard

SAMPLERS: (Signature) Andrea Leeson, Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH 8015	BTEX 8240	Container No.	Number of Containers	Remarks
4.1.96	1100	RMI-VW3-1.5-2.0	✓	✓		1	Brass Slee
4.1.96	1100	RMI-VW3-2.5-3.0	✓	✓		"	"
4.1.96	1108	RMI-VW3-3.5-4.0	✓	✓		"	"
4.1.96	1108	RMI-VW3-4.5-5.0	✓	✓		"	"
4.1.96	1120	RMI-VW3-5.5-6.0	✓	✓		"	"
4.1.96	1120	RMI-VW3-6.5-7.0	✓	✓		"	"
4.1.96	1156	RMI-VW3-7.5-8.0	✓	✓		"	"
4.1.96	1156	RMI-VW3-8.5-9.0	✓	✓		"	"
4.1.96	1217	RMI-VW3-9.0-9.5	✓	✓		"	"
4.1.96	1217	RMI-VW3-10.0-10.5	✓	✓		"	"
4.1.96	1230	RMI-VW3-11.0-11.5	✓	✓		"	"
4.1.96	1230	RMI-VW3-12.0-12.5	✓	✓		"	"
4.1.96	1250	RMI-VW3-13.0-13.5	✓	✓		"	"
4.1.96	1250	RMI-VW3-14.0-14.5	✓	✓		"	"
4.1.96	1305	RMI-VW3-15.5-16.0	✓	✓		"	"
4.1.96	1305	RMI-VW3-16.5-17.0	✓	✓		"	"
4.1.96	1330	RMI-VW3-17.0-17.5	✓	✓		"	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[signature]	4.2.96 1229				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	4/3/96 1000		

Page ___ of ___

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. Page 2 of 2

Proj. No. G002737-01

Project Title: Rhein-Main Air Base POL Yard

SAMPLERS: (Signature) Andrea Leeson, Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH 8015	BTEX 8240	Container No.	Number of Containers	Remarks
4.1.96	1330	RMI-VW3-18.0-18.5	✓	✓		1 Brass sleeve	
4.2.96	0900	RMI-VW3-23.5-24.0	✓	✓		1 Brass sleeve	(Below water table)
4.2.96	0900	RMI-VW3-24-24.5	✓	✓		"	Below water table
4.2.96	0951	RMI-VW3-26-26.5	✓	✓		"	
4.2.96	0951	RMI-VW3-26.5-27	✓	✓		"	
4.2.96	1052	RMI-VW3-27.5-28	✓	✓		"	"
4.2.96	1052	RMI-VW3-28-28.5	✓	✓		"	"

Please contact Al Pollack @ 614/424-3753 about analyses for TPH.

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[signature]	4.29.96 1229				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	4/3/96 1000		

Billing Information:

Name
Address
City, State, Zip
Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 1 of 2

Client Name: Battelle
P.O. #: 6002737-01
Address:
Phone #:
City, State, Zip:
Report Attention: Al Pollack
Sampled by: Rhein-Main AFB Germany

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH	BTEX	Analyses Required						Remarks
	4/1	SO	BMI040396-01	RMI-VW3-1.5-2.0	1	X	+							
			02	RMI-VW3-2.5-3.0	1	X	+							
			03	RMI-VW3-3.5-4.0	1	X	+							
			04	RMI-VW3-4.5-5.0	1	X	+							
			05	RMI-VW3-5.5-6.0	1	X	+							
			06	RMI-VW3-6.5-7.0	1	X	+							
			07	RMI-VW3-7.5-8.0	1	X	+							
			08	RMI-VW3-8.5-9.0	1	X	+							
			09	RMI-VW3-9.0-9.5	1	X	+							
			10	RMI-VW3-10.0-10.5	1	X	+							
			11	RMI-VW3-11.0-11.5	1	X	+							
			12	RMI-VW3-12.0-12.5	1	X	+							
			13	RMI-VW3-13.0-13.5	1	X	+							
			14	RMI-VW3-14.0-14.5	1	X	+							
			15	RMI-VW3-15.5-16.0	1	X	+							
			16	RMI-VW3-16.5-17.0	1	X	+							

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/3/96	1000
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Billing Information:

Name
Address
City, State, Zip
Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle
P.O. #
Address
Phone #
City, State, Zip
Report Attention: Al Pollock
Sampled by: Germany

Analyses Required: TPH/G, BTXE

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH/G	BTXE	Remarks
	4/1	SO	BMI040396-17	RMI-VW3-17.0-17.5	1	X	+	
	↓	↓	18	RMI-VW3-18.0-18.5	1	X	+	
			19	RMI-VW3-23.5-24.0	1	X	+	
			20	RMI-VW3-24-24.5	1	X	+	
			21	RMI-VW3-26-26.5	1	X	+	
			22	RMI-VW3-26.5-27	1	X	+	
			23	RMI-VW3-27.5-28	1	X	+	
	↓	↓	24	RMI-VW3-28-28.5	1	X	+	

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydaik	Linda Bydaik	AAI	4/3/96	1000
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

Laboratory Analysis Report

Sierra Environmental Monitoring, Inc.

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date : 4/25/96
Client : ALP-855
Taken by: CLIENT
Report : 15982
PO# :

Page: 1

Sample	Collected Date	Time	BROMIDE MG/L	AQUEOUS EXTRACT				
BMI040596-22-RM1-VW1-21.8-22.3	4/03/96	:	220 mg/kg	YES				
BMI040596-23-RM1-VW1-22.3-22.8	4/03/96	:	16 mg/kg	YES				
BMI040596-24-RM1-VW1-24.3-24.8	4/03/96	:	1.8 mg/kg	YES				
BMI040596-25-RM1-VW1-24.8-25.3	4/03/96	:	<1 mg/kg	YES				
BMI040596-26-INITIAL SOLUTION	4/03/96	:	30,670					
BMI040596-27-DOWNHOLE H20 VW1	4/03/96	:	2,480					
BMI040596-28-DOWNHOLE H20 7.1M	4/03/96	:	310					
BMI040596-29-SECOND SOLUTION	4/03/96	:	22,480					
BMI040596-30-DOWNHOLE H20 7.8M	4/03/96	:	550					
BMI040596-31-DOWNHOLE H20 8.5M	4/03/96	:	420					
BMI040596-32-RM1-VW1-26.1-26.6	4/03/96	:	125 mg/kg	YES				
BMI040596-33-RM1-VW1-26.6-27.1	4/03/96	:	48 mg/kg	YES				
BMI040596-34-RM1-VW1-27.1-26.6	4/03/96	:	64 mg/kg	YES				
BMI040596-35-RM1-VW1-28.9-29.4	4/03/96	:	<1 mg/kg	YES				
BMI040596-36-RM1-VW1-29.4-29.9	4/03/96	:	2.6 mg/kg	YES				
BMI040596-37-RM1-VW1-28.4-28.9	4/03/96	:	1.9 mg/kg	YES				

proved By:

William F. Pillsbury
President

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

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2505 Chandler Avenue, Suite 1
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ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 04/02-03/96 Received: 04/05/96 Analyzed: 04/09-15/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW1-2.0-2.5 /BMI040596-01	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-2.5-3.0 /BMI040596-02	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-3.5-4.0 /BMI040596-03	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-4.5-5.0 /BMI040596-04	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit
RM1-VW1-5.5-6.0 /BMI040596-05	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW1-6.5-7.0 /BMI040596-06	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW1-7.5-8.0 /BMI040596-07	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW1-8.5-9.0 /BMI040596-08	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW1-9.5-10.0 /BMI040596-09	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW1-10.5-11.0 /BMI040596-10	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg
RM1-VW1-11.5-12.0 /BMI040596-11	TPH (Purgeable)	ND	10 mg/Kg
	Benzene	ND	20 ug/Kg
	Toluene	ND	20 ug/Kg
	Ethylbenzene	ND	20 ug/Kg
	Total Xylenes	ND	20 ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW1-12.5-13.0 /BMI040596-12	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-13.5-14.0 /BMI040596-13	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-14.5-15.0 /BMI040596-14	TPH (Purgeable)	150	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-15.3-15.8 /BMI040596-15	TPH (Purgeable)	1,000	100	mg/Kg
	Benzene	ND	200	ug/Kg
	Toluene	ND	200	ug/Kg
	Ethylbenzene	ND	200	ug/Kg
	Total Xylenes	ND	200	ug/Kg
RM1-VW1-15.8-16.3 /BMI040596-16	TPH (Purgeable)	280	17	mg/Kg
	Benzene	ND	33	ug/Kg
	Toluene	ND	33	ug/Kg
	Ethylbenzene	ND	33	ug/Kg
	Total Xylenes	ND	33	ug/Kg
RM1-VW1-17.2-17.17 /BMI040596-17	TPH (Purgeable)	73	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-17.7-18.2 /BMI040596-18	TPH (Purgeable)	45	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW1-18.2-18.7 /BMI040596-19	TPH (Purgeable)	47	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-19.2-19.7 /BMI040596-20	TPH (Purgeable)	66	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-19.7-20.2 /BMI040596-21	TPH (Purgeable)	17	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-21.8-22.3 /BMI040596-22	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-22.3-22.8 /BMI040596-23	TPH (Purgeable)	21	10	mg/Kg
	Benzene	61	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW1-24.3-24.8 /BMI040596-24	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	830	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	83	20	ug/Kg
	Total Xylenes	270	20	ug/Kg
RM1-VW1-24.8-25.3 /BMI040596-25	TPH (Purgeable)	78	10	mg/Kg
	Benzene	520	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	190	20	ug/Kg
	Total Xylenes	620	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW1-26.1-26.6 /BMI040596-32	TPH (Purgeable)	180	50	mg/Kg
	Benzene	100	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	290	100	ug/Kg
	Total Xylenes	1,000	100	ug/Kg
RM1-VW1-26.6-27.1 /BMI040596-33	TPH (Purgeable)	4,100	500	mg/Kg
	Benzene	7,200	1,000	ug/Kg
	Toluene	2,500	1,000	ug/Kg
	Ethylbenzene	15,000	1,000	ug/Kg
	Total Xylenes	61,000	1,000	ug/Kg
RM1-VW1-27.1-26.6 /BMI040596-34	TPH (Purgeable)	3,400	500	mg/Kg
	Benzene	4,800	1,000	ug/Kg
	Toluene	2,300	1,000	ug/Kg
	Ethylbenzene	13,000	1,000	ug/Kg
	Total Xylenes	55,000	1,000	ug/Kg
RM1-VW1-28.9-29.4 /BMI040596-35	TPH (Purgeable)	26	10	mg/Kg
	Benzene	1,100	20	ug/Kg
	Toluene	44	20	ug/Kg
	Ethylbenzene	170	20	ug/Kg
	Total Xylenes	630	20	ug/Kg
RM1-VW1-29.4-29.9 /BMI040596-36	TPH (Purgeable)	32	10	mg/Kg
	Benzene	820	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	84	20	ug/Kg
	Total Xylenes	380	20	ug/Kg
RM1-VW1-28.4-28.9 /BMI040596-37	TPH (Purgeable)	10	10	mg/Kg
	Benzene	120	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	23	20	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 4/19/96
Roger L. Scholl, Ph.D.
Laboratory Director

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. Page 1 / 3

Proj. No. G002737-01

Project Title Rhein-Main Air Base, POL YARD

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
✓4.2.96	1527	RMI-VWI-2.0-2.5	X	X		1	Brass sleeve
✓4.2.96	1527	RMI-VWI-2.5-3.0	X	X		"	"
✓4.2.96	1537	RMI-VWI-3.5-4.0	X	X		"	"
✓4.2.96	1537	RMI-VWI-4.5-5.0	X	X		"	"
✓4.2.96	1557	RMI-VWI-5.5-6.0	X	X		"	"
✓4.2.96	1557	RMI-VWI-6.5-7.0	X	X		"	"
✓4.2.96	1614	RMI-VWI-7.5-8.0	X	X		"	"
✓4.2.96	1614	RMI-VWI-8.5-9.0	X	X		"	"
✓4.3.96	0810	RMI-VWI-9.5-10.0	X	X		"	"
✓4.3.96	0810	RMI-VWI-10.5-11.0	X	X		"	"
✓4.3.96	0849	RMI-VWI-11.5-12.0	X	X		"	"
✓4.3.96	0849	RMI-VWI-12.5-13.0	X	X		"	"
✓4.3.96	0916	RMI-VWI-13.5-14.0	X	X		"	"
✓4.3.96	0916	RMI-VWI-14.5-15.0	X	X		"	"
✓4.3.96	0932	RMI-VWI-15.3-15.8	X	X		"	"
✓4.3.96	0932	RMI-VWI-15.8-16.3	X	X		"	"
✓4.3.96	0958	RMI-VWI-17.2-17.7	X	X		"	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[signature]	4.3.96 1525				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	4/5/96 1030		

Page 1 of 3

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. Page 2/3

Proj. No. G002737-01

Project Title: Rhein-Main Air Base, POL YARD

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

3

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Bromide	Container No.	Number of Containers	Remarks
✓4.3.96	0958	RMI-VWI-17.7-18.2	X	X			1	Brass sleeve
✓4.3.96	0958	RMI-VWI-18.2-18.7	X	X			"	"
✓4.3.96	1034	RMI-VWI-19.2-19.7	X	X			"	"
✓4.3.96	1034	RMI-VWI-19.7-20.2	X	X			"	"
✓4.3.96	1303	RMI-VWI-21.8-22.3	X	X			1	Brass sleeve, below H_2O
✓4.3.96	1303	RMI-VWI-22.3-22.8	X	X			"	" "
✓4.3.96	1339	RMI-VWI-24.3-24.8	X	X			"	" "
✓4.3.96	1339	RMI-VWI-24.8-25.3	X	X			"	" "
✓4.3.96	1205	Initial Solution			X		40ml	VOA vile (Q[illegible]
✓4.3.96	1240	Downhole H_2O-VWI			X		"	" " "
✓4.3.96	1315	Downhole H_2O-VWI-7.1m			X		"	" " "
✓4.3.96	1310	Second Solution			X		"	" " "
✓4.3.96	1355	Downhole H_2O-VWI-7.8m			X		"	" " "
✓4.3.96	1435	Downhole H_2O-VWI-8.5m			X		"	" " "

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[signature]	4.3.96 1525				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		[signature]	4/5/96 1030	

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. Page 3/3

Proj. No. G002737-01

Project Title Rhein-Main Air Base, POL Yard

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
4.3.96	1423	RMI-VWI-26.1-26.6	X	X		(Below H2O)	1 Brass sleev.
4.3.96	1423	RMI-VWI-26.6-27.1	X	X		"	" "
4.3.96	1433	*RMI-VWI-27.1-26.6	✓	✓		"	" "
4.3.96	1511	RMI-VWI-28.9-29.4	✓	✓		"	" "
4.3.96	1511	RMI-VWI-29.4-29.9	✓	✓		"	" "
4.3.96	1511	RMI-VWI-28.4-28.9	✓	✓		"	" "

*[illegible] 27.1-[illegible]

Relinquished by: (Signature)	Date/Time		Received by: (Signature)	Relinquished by: (Signature)	Date/Time		Received by: (Signature)
[signature]	4.3.96	1525					
Relinquished by: (Signature)	Date/Time		Received by: (Signature)	Relinquished by: (Signature)	Date/Time		Received by: (Signature)
Relinquished by: (Signature)	Date/Time		Received for Laboratory by: (Signature)	Date/Time		Remarks	
			[signature]	4/5/96	1030		

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle

Address:

City, State, Zip:

P.O. # G002737-01

Phone #

Report Attention: Al Pollock

Sampled by: Jeremy

Analyses Required: BTXE

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	BTXE	Remarks
	4/2	SO	BMI040596-01	RMI-VWI-2.0-2.5	1	X	BRASS
	↓	↓	02	RMI-VWI-2.5-3.0	1	X	
	↓	↓	03	RMI-VWI-3.5-4.0	1	X	
	↓	↓	04	RMI-VWI-4.5-5.0	1	X	
	↓	↓	05	RMI-VWI-5.5-6.0	1	X	
	↓	↓	06	RMI-VWI-6.5-7.0	1	X	
	↓	↓	07	RMI-VWI-7.5-8.0	1	X	
	↓	↓	08	RMI-VWI-8.5-9.0	1	X	
	4/3	↓	09	RMI-VWI-9.5-10.0	1	X	
	↓	↓	10	RMI-VWI-10.5-11.0	1	X	
	↓	↓	11	RMI-VWI-11.5-12.0	1	X	
	↓	↓	12	RMI-VWI-12.5-13.0	1	X	
	↓	↓	13	RMI-VWI-13.5-14.0	1	X	
	↓	↓	14	RMI-VWI-14.5-15.0	1	X	
	↓	↓	15	RMI-VWI-15.3-15.8	1	X	
	↓	↓	16	RMI-VWI-15.8-16.3	1	X	

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/5/96	1030
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle | P.O. #

Address | Phone #

City, State, Zip | Report Attention

Sampled by: Jes muny

Analyses Required: BTXE, Bromide

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	BTXE	Bromide						Remarks
	4/3	SO	BMI040596-17	RMI-VWI-17.2-17.17	1	X							
	↓	↓	18	RMI-VWI-17.7-18.2	1	X							
			19	RMI-VWI-18.2-18.7	1	X							
			20	RMI-VWI-19.2-19.7	1	X							
			21	RMI-VWI-19.7-20.2	1	X							
			22	RMI-VWI-21.8-22.3	1	X	X						
			23	RMI-VWI-22.3-22.8	1	X	X						
			24	RMI-VWI-24.3-24.8	1	X	X						
		~~SO~~	25	RMI-VWI-24.8-25.3	1	X	X						
		AQ	26	Initial Solution	1		X						
			27	Downhole H2O-VWI	1		X						
			28	Downhole H2O-VWI-7.1m	1		X						
			29	Second Solution	1		X						
			30	Downhole H2O-VWI-7.8m	1		X						
		↓	31	Downhole H2O-VWI-8.5m	1		X						
	↓	SO	32	RMI-VWI-26.1-26.6	1	X	X						

	Signature	Print Name	Company	Date	Time
Relinquished by	Linda Bydairk	Linda Bydairk	AAI	4/5/96	1030
Received by					
Relinquished by	[signature]	Craig Giesy	AAI	4/8/96	1545
Received by	[signature]	[signature]	SEM	4/8/96	1545
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 3 of 3

Client Name: Dattilo

P.O. #

Address

Phone #

City, State, Zip

Report Attention

Sampled by: Germany

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	BTXE	Bromide							Remarks
	4/3	SO	BMI040596-33	RMI-VWI-26.6-27.1	1	X	X							Brass
			*34	RMI-VWI-27.1-26.6	1	X	X							
			35	RMI-VWI-28.9-29.4	1	X	X							* Dattilo's
			36	RMI-VWI-29.4-29.9	1	X	X							COC SAYS
			37	RMI-VWI-28.4-28.9	1	X	X							27.1-26.6
						X	X							Brass tube
						X	X							says 27.1-27.
						X	X							
						X	X							
		50 RG												

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/5/96	1030
Relinquished by	[illegible]	CRAIG GIESY	AAI	4/8/96	1545
Received by	[illegible]	[illegible]	SCM	4/8/96	1545
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
(702) 355-1044
FAX: 702-355-0406
1-800-283-1183

e-mail: alpha@powernet.net
http//www.powernet.net/~alpha

2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#:
Phone: (614) 424-3783
Attn: Al Pollock

Sampled: 04/05/96 Received: 04/10/96 Analyzed: 04/14/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW4-7.41-7.57m /BMI041096-37	TPH (Purgeable)	120	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW4-7.90-8.06m /BMI041096-41	TPH (Purgeable)	660	170	mg/Kg
	Benzene	ND	330	ug/Kg
	Toluene	ND	330	ug/Kg
	Ethylbenzene	ND	330	ug/Kg
	Total Xylenes	ND	330	ug/Kg
RM1-VW4-9.18-9.34m /BMI041096-45	TPH (Purgeable)	170	50	mg/Kg
	Benzene	120	100	ug/Kg
	Toluene	760	100	ug/Kg
	Ethylbenzene	310	100	ug/Kg
	Total Xylenes	760	100	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 4/19/96
Roger L. Scholl, Ph.D.
Laboratory Director

Laboratory Analysis Report

Sierra Environmental Monitoring, Inc.

ALPHA ANALYTICAL
255 GLENDALE AVENUE, SUITE 21
SPARKS NV 89431

Date : 5/10/96
Client : ALP-855
Taken by: CLIENT
Report : 16004
PO# :

Page: 1

Sample	Collected Date	Time	ALKALINITY MG/L CACO3	PH S.U.	MOISTURE CONTENT %	KJELDAHL-N MG/L	PHOSPHORUS -TOTAL MG/L	IRON, ICP MG/L
BMI041096-23-RM1-VW4-1.5-1.66	4/04/96	:	70 mg/kg	7.37	6.4%	0.49 mg/g	26mg/kg	8.3 mg/g
BMI041096-26-RM1-VW4-3.05-3.21	4/04/96	:	120 mg/kg	8.24	10.0	<0.1 mg/g	43mg/kg	2.7 mg/g
BMI041096-29-RM1-VW4-4.87-5.04	4/04/96	:	210 mg/kg	8.22	5.7	0.63 mg/g	94mg/kg	2.5 mg/g
BMI041096-32-RM1-VW4-5.79-5.96	4/04/96	:	90 mg/kg	7.94	4.5	<0.1 mg/g	25mg/kg	250 ug/g
BMI041096-34-RM1-VW4-6.44-6.60	4/04/96	:	400 mg/kg	9.09	5.4	0.16 mg/g	83mg/kg	2.1 mg/g
BMI041096-38-RM1-VW4-7.09-7.25	4/04/96	:	80 mg/kg	8.19	12.8	6.3 mg/g	14mg/kg	270 ug/g
BMI041096-42-RM1-VW4-8.06-8.22	4/04/96	:	70 mg/kg	8.57	12.7	<0.1 mg/g	13mg/kg	900 ug/g

Sample	Collected Date	Time	SULFATE MG/L	SULFIDE ** MG/L	SIEVE ANALYSIS	DIGESTION-TOTAL METALS	AQUEOUS EXTRACT	
BMI041096-22A/B-RM1-1.82/2.15	4/04/96	:			yes			
BMI041096-23-RM1-VW4-1.5-1.66	4/04/96	:				yes	yes	
BMI041096-24-RM1-VW4-1.66-1.22	4/04/96	:	26 mg/kg	130 mg/kg			yes	
BMI041096-25A/B-RM1-3.38/3.70	4/04/96	:			yes			
BMI041096-26-RM1-VW4-3.05-3.21	4/04/96	:				yes	yes	
BMI041096-27-RM1-VW4-3.21-3.38	4/04/96	:	28 mg/kg	20 mg/kg			yes	
BMI041096-28A/B-RM1-5.20/5.52	4/04/96	:			yes			
BMI041096-29-RM1-VW4-4.87-5.04	4/04/96	:				yes	yes	
BMI041096-30-RM1-VW4-5.04-5.20	4/04/96	:	11 mg/kg	80 mg/kg			yes	
BMI041096-31A/B-RM1-6.12/6.44	4/04/96	:			yes			
BMI041096-32-RM1-VW4-5.79-5.96	4/04/96	:				yes	yes	
BMI041096-33-RM1-VW4-5.96-6.12	4/04/96	:	17 mg/kg	20 mg/kg			yes	
BMI041096-34-RM1-VW4-6.44-6.60	4/04/96	:				yes	yes	
BMI041096-35-RM1-VW4-6.60-6.76	4/04/96	:	32 mg/kg	10 mg/kg			yes	
BMI041096-36A/B-RM1-6.76/7.09	4/04/96	:			yes			
BMI041096-38-RM1-VW4-7.09-7.25	4/04/96	:				yes	yes	
BMI041096-39-RM1-VW4-7.25-7.41	4/04/96	:	40 mg/kg	60 mg/kg			yes	
BMI041096-40A/B-RM1-7.57/7.90	4/04/96	:			yes			
BMI041096-42-RM1-VW4-8.06-8.22	4/04/96	:				yes	yes	
3MI041096-43-RM1-VW4-8.39-8.78	4/04/96	:			yes			
3MI041096-44-RM1-VW4-8.78-8.95	4/04/96	:			yes			
3MI041096-46-RM1-VW4-9.02-9.18	4/04/96	:	50 mg/kg	10 mg/kg			yes	
3MI041096-47A/B-RM1-9.34/9.66	4/04/96	:			yes			

** - Analysis performed by Barringer Laboratory

pproved By:

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

Villiam F. Pillsbury
resident

John C. Seher
Manager

BARRINGER LABORATORIES INC.

15000 W. 6TH AVE., SUITE 300
GOLDEN, COLORADO 80401
PHONE: (303) 277-1687

5301 LONGLEY LANE
BUILDING E, SUITE 178
RENO, NEVADA 89511
PHONE: (702) 828-1158

8-May-96

SIERRA ENVIROMENTAL
1135 FINANCIAL BLVD
RENO NV 89502

Page: 1
Copy: 1 of 2
Set : 1

Attn:
Project:

Received: 22-Apr-96 11:55
PO #: 2038

Job: 961269R Status: Final

Soil

Sample	S Leco %	SO4 Leco %	S- Leco %	
9604-383	0.028	0.046	0.013	- BMI041096-24
9604-386	0.007	0.015	0.002	- BMI041096-27
9604-389	0.014	0.018	0.008	- BMI041096-30
9604-392	0.007	0.018	0.002	- BMI041096-33
9604-394	0.006	0.015	0.001	- BMI041096-35
9604-397	0.011	0.015	0.006	- BMI041096-39
9604-402	0.001	0.003	0.001	- BMI041096-46

BARRINGER LABORATORIES INC.

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RENO, NEVADA 89511
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8-May-96

SIERRA ENVIROMENTAL
1135 FINANCIAL BLVD
RENO NV 89502

Attn:
Project:

Received: 22-Apr-96 11:55
PO #: 2038

Job: 961269R   Status: Final

Abbreviations:

Parameters:

S	:	Sulfur
SO4	:	Sulfate Ion
S-	:	Sulfide

Methods:

Leco	:	Leco Sulfer/Carbon Analysis

Units:

%	:	percent

15000 W. 6TH AVE., SUITE 300
GOLDEN, COLORADO 80401
PHONE: (303) 277-1687

5301 LONGLEY LANE
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RENO, NEVADA 89511
PHONE: (702) 828-1158

BARRINGER LABORATORIES INC.

8-May-96

SIERRA ENVIROMENTAL
1135 FINANCIAL BLVD
RENO NV 89502

Attn:
Received: 22-Apr-96 11:55
Project:
PO #: 2038

Job: 961269R Status: Final

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim or deposit has been determined based on the results of assays of multiple samples of geologic materials collected by the prospective investor or by a qualified person selected by him and based on an evaluation of all engineering data which is available concerning any proposed project.

Job approved by:

Signed: Richard A. Bruodin

Sierra
Environmental
Monitoring, Inc.

Sierra Environmental Monitoring, Inc.
1135 Financial Bloulevard
Reno, NV 89502
702-857-2400 FAX 702-857-2404

SIEVE ANALYSIS REPORT

Client	Allpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-22A/B-RM1-1.82/2.15	Sample Date	04/04/96
SEM Lab Number	9406-0381	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	74%
No. 4	73%
No. 8	63%
No. 10	59%
No. 16	44%
No. 30	20%
No. 40	14%
No. 50	9%
No. 100	<1.0 %
No. 200	<1.0 %
> 200	<1.0 %

Approved by: [signature]

John Seher, Laboratory Manager

Sierra
Environmental
Monitoring, Inc.

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1135 Financial Bloulevard
Reno, NV 89502
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SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-25A/B-RM1-3.83/3.70	Sample Date	04/04/96
SEM Lab Number	9406-0384	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	76%
No. 4	58%
No. 8	46%
No. 10	41%
No. 16	29%
No. 30	13%
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %
> 200	<1.0 %

Approved by: [signature]

John Seher, Laboratory Manager

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Reno, NV 89502
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SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-28A/B-RM1-5.20/5.52	Sample Date	04/04/96
SEM Lab Number	9406-0387	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	95%
1/2 inch	86%
No. 4	64%
No. 8	54%
No. 10	<1.0 %
No. 16	<1.0 %
No. 30	<1.0 %
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %
>200	<1.0 %

Approved by: ____________________

John Seher, Laboratory Manager

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SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-31A/B-RM1-6.12/6.44	Sample Date	04/04/96
SEM Lab Number	9604-0390	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	86%
No. 4	72%
No. 8	64%
No. 10	59%
No. 16	46%
No. 30	19%
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %

Approved by: [signature]

John Seher, Laboratory Manager

illiam F. Pillsbury
resident

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John C. Seher
Manager

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SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-36A/B-RM1-6.76/7.09	Sample Date	04/04/96
SEM Lab Number	9604-0395	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	100%
No. 4	94%
No. 8	84%
No. 10	77%
No. 16	53%
No. 30	16%
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %

Approved by: ______________________

John Seher, Laboratory Manager

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Villiam F. Pillsbury
?resident

John C. Seher
Manager

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SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-40A/B-RM1-7.57/7.90	Sample Date	04/04/96
SEM Lab Number	9604-0398	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	96%
No. 4	93%
No. 8	89%
No. 10	86%
No. 16	70%
No. 30	25%
No. 40	11%
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %

Approved by: [signature]

John Seher, Laboratory Manager

Sierra
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Monitoring, Inc.

Sierra Environmental Monitoring, Inc.
1135 Financial Bloulevard
Reno, NV 89502
702-857-2400 FAX 702-857-2404

SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-43-RM1-VW4-8.39/8.78	Sample Date	04/04/96
SEM Lab Number	9604-0400	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	89%
No. 4	61%
No. 8	43%
No. 10	38%
No. 16	26%
No. 30	10%
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %

Approved by: John Seher

John Seher, Laboratory Manager

Villiam F. Pillsbury
President

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Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

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Sierra Environmental Monitoring, Inc.
1135 Financial Bloulevard
Reno, NV 89502
702-857-2400 FAX 702-857-2404

SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-44-RM1-VW4-8.78-8.95	Sample Date	04/04/96
SEM Lab Number	9604-0401	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	93%
No. 4	63%
No. 8	41%
No. 10	36%
No. 16	23%
No. 30	11%
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %

Approved by: [signature]

John Seher, Laboratory Manager

/illiam F. Pillsbury
'resident

1135 Financial Blvd.
Reno, NV 89502
Phone (702) 857-2400
FAX (702) 857-2404

John C. Seher
Manager

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Monitoring, Inc.

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1135 Financial Bloulevard
Reno, NV 89502
702-857-2400 FAX 702-857-2404

SIEVE ANALYSIS REPORT

Client	Alpha Analytical, Inc.	Analytical Method	ASTM
Sample Name	BMI041096-47A/B-RM1-9.34-9.66	Sample Date	04/04/96
SEM Lab Number	9604-0404	Analysis Date	05/03/96

U. S. Standard Sieve Size	Percent Passing
1 inch	100%
1/2 inch	94%
No. 4	74%
No. 8	52%
No. 10	46%
No. 16	30%
No. 30	12%
No. 40	<1.0 %
No. 50	<1.0 %
No. 100	<1.0 %
No. 200	<1.0 %

Approved by: John Seher

John Seher, Laboratory Manager

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 1/2

Proj. No.	Project Title
G002737-01	Rhein-Main AB, POL Yard

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

SAMPLE TYPE (✓)

DATE	TIME	SAMPLE I.D.	Particle Size / Sieve	Alkalinity 310.1	Ion 200.7	Moisture Content ASTM	pH 150.1	Sulfate ICAP	Sulfide ICAP	TKN 351.4	Total Phosphorus 365.2	Container No.	Number of Containers	Remarks
✓ 4.4.96	1155	RMI-VW4-1.82-1.98m	✓									Composite	2	Brass sleeves
✓ 4.4.96	1155	RMI-VW4-1.98-2.15m	✓											
✓ 4.4.96	1155	RMI-VW4-1.5-1.66m		✓	✓	✓	✓			✓	✓		1	Brass sleeve
✓ 4.4.96	1155	RMI-VW4-1.66-1.87m						✓	✓				1	Brass sleeve
✓ 4.4.96	1230	RMI-VW4-3.38-3.54m	✓									Composite	2	Brass sleeves
✓ 4.4.96	1230	RMI-VW4-3.54-3.70m	✓											
✓ 4.4.96	1230	RMI-VW4-3.05-3.21m		✓	✓	✓	✓			✓	✓		1	Brass sleeve
✓ 4.4.96	1230	RMI-VW4-3.21-3.38m						✓	✓				1	Brass sleeve
✓ 4.4.96	1310	RMI-VW4-5.20-5.36m	✓									Composite	2	Brass sleeve
✓ 4.4.96	1310	RMI-VW4-5.36-5.52m	✓											
✓ 4.4.96	1310	RMI-VW4-4.87-5.04m		✓	✓	✓	✓			✓	✓		1	Brass sleeve
✓ 4.4.96	1310	RMI-VW4-5.04-5.20m						✓	✓				1	Brass sleeve
✓ 4.4.96	1350	RMI-VW4-6.12-6.28m	✓									Composite	2	Brass sleeve
✓ 4.4.96	1350	RMI-VW4-6.28-6.44m	✓											
✓ 4.4.96	1350	RMI-VW4-5.79-5.96m		✓	✓	✓	✓			✓	✓		1	Brass sleeve
✓ 4.4.96	1350	RMI-VW4-5.96-6.12m						✓	✓				1	Brass sleeve

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	4/9/96 1245				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	4/10/96 1030		

- 1 - 2.

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 2/2

Proj. No.	Project Title
G002737-01	Rhein-Main Air Base, POL Yard

SAMPLERS: (Signature) Chris Perry, Walter Sebenlist

SAMPLE TYPE (√'s)

DATE	TIME	SAMPLE I.D.	Particle Size U Sieve	Alkalinity 310.1	Iron 200.7	Moisture Content ASTM	pH 150.1	Sulfate ICAP	Sulfide ICAP	TKN 351.4	Total Phosphorus 365.2	TPH-8015	BTEX-8240				Container No.	Number of Containers	Remarks
√ 4.4.96	15 12	RMI-VW4-6.44-6.60m		√	√	√	√			√	√							1	Brass sleeve
√ 4.4.96	15 15	RMI-VW4-6.60-6.76m						√	√									"	" "
√ 4.4.96	15 12	RMI-VW4-6.76-6.92m	√														3 Composite	2	Brass sleeves
√ 4.4.96	15 12	RMI-VW4-6.92-7.09m	√																
√ 4.5.96	08 44	RMI-VW4-7.41-7.57m										√	√					1	Brass sleeve
√ 4.5.96	08 44	RMI-VW4-7.09-7.25m		√	√	√	√			√	√							"	" "
√ 4.5.96	08 44	RMI-VW4-7.25-7.41m						√	√									"	" "
√ 4.5.96	08 44	RMI-VW4-7.57-7.74m	√														3 Composite	2	Brass sleeves
√ 4.5.96	09 14	RMI-VW4-7.74-7.90m	√																
√ 4.5.96	09 14	RMI-VW4-7.90-8.06m										√	√					1	Brass sleeve
√ 4.5.96	09 14	RMI-VW4-8.06-8.22m		√	√	√	√			√	√							"	" "
√ 4.5.96	10 05	RMI-VW4-8.38-8.78m	√															1	Zip-loc bags
√ 4.5.96	10 05	RMI-VW4-8.78-8.95m	√															1	Zip-loc bags
√ 4.5.96	10 20	RMI-VW4-9.18-9.34m										√	√					1	Brass sleeves
√ 4.5.96	10 20	RMI-VW4-9.02-9.18m						√	√									"	" "
√ 4.5.96	10 20	RMI-VW4-9.34-9.50m	√														3 Composite	2	Brass sleeves
√ 4.5.96	10 20	RMI-VW4-9.50-9.66m	√																

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	4/9/96 1245				
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**
Relinquished by: (Signature)	**Date/Time**	**Received for Laboratory by: (Signature)**	**Date/Time**	**Remarks**	
		[signature]	4/10/96 1030		

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Dathill

P.O. # 6002 737-01

Address:

Phone #:

City, State, Zip:

Report Attention: Al Pollack

Sampled by: Germany

Analyses Required

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers		Particle Size	Alkalinity 310.1	Iron 200.7	Moisture Content ASTM	pH 150.1	Sulfate Hcap	Sulfide Hcap	TKN 351.4	Total P 365.2	Remarks
	4/4	SO	BMI041096-22A	RMI-VW4-1.82-1.98m	1	comp	✓									MASS 3 composite
			22B	RMI-VW4-1.98-2.15m	1		✓									
			23	RMI-VW4-1.5-1.66m	1			✓	✓	✓	✓			✓	✓	
			24	RMI-VW4-1.66-1.82m	1							✓	✓			
			25A	RMI-VW4-3.38-3.54m	1	comp	✓									3 composite
			25B	RMI-VW4-3.54-3.70m	1		✓									
			26	RMI-VW4-3.05-3.21m	1			✓	✓	✓	✓			✓	✓	
			27	RMI-VW4-3.21-3.38m	1							✓	✓			
			28A	RMI-VW4-5.20-5.36m	1	comp	✓									3 composite
			28B	RMI-VW4-5.36-5.52m	1		✓									
			29	RMI-VW4-4.87-5.04m	1			✓	✓	✓	✓			✓	✓	
			30	RMI-VW4-5.04-5.20m	1							✓	✓			
			31A	RMI-VW4-6.12-6.28	1	comp	✓									3 composite
			31B	RMI-VW4-6.28-6.44m	1		✓									
			32	RMI-VW4-5.79-5.96m	1			✓	✓	✓	✓			✓	✓	
			33	RMI-VW4-5.96-6.12m	1							✓	✓			

11 sieve

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Brdaik	Linda Brdaik	AAI	4/10/96	1030
Relinquished by	[signature]	Craig Giesy	AAI	4/10/96	1415
Received by	[signature]	[signature]	SCM	4/10/96	1415
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle

Address:

City, State, Zip:

P.O. #:

Phone #: 3753

Report Attention: Al Pollack

Sampled by: Germany

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	Particle Size / Sieve	Alkalinity 310.1	Iron 200.7	Moisture Content	pH 150.1	Sulfate Ecap	Sulfide Ecap	TKN 351.4	Total P 365.2	TPH/O&G	BTEX	Remarks
	4/4	SO	BMI-041096-34	RMI-VW4-6.44-6.60m	1		✓	✓	✓	✓			✓	✓			
			35	RMI-VW4-6.60-6.76m	1						✓	✓					
			36A	RMI-VW4-6.76-6.92m	1	✓	composite										composite
			36B	RMI-VW4-6.92-7.09m	1	✓											
	4/5		37	RMI-VW4-7.41-7.57m	1										✓	✓	
			38	RMI-VW4-7.09-7.25m	1		✓	✓	✓	✓			✓	✓			
			39	RMI-VW4-7.25-7.41m	1						✓	✓					
			40A	RMI-VW4-7.57-7.74m	1	✓	comp										composite
			40B	RMI-VW4-7.74-7.90m	1	✓											
			41	RMI-VW4-7.90-8.06m	1										✓	✓	
			42	RMI-VW4-8.06-8.22m	1		✓	✓	✓	✓			✓	✓			
			43	RMI-VW4-8.38-8.78m	1	✓											
			44	RMI-VW4-8.78-8.95m	1	✓											
			45	RMI-VW4-9.18-9.34m	1										✓	✓	
			46	RMI-VW4-9.02-9.18	1						✓	✓					
			47A	RMI-VW4-9.34-9.50m	1	✓	comp.										composite
			47B	RMI-VW4-9.50-9.66m	1	✓											

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	[signature]	Linda Bydairk	AAI	4/10/96	1030
Relinquished by	[signature]	Craig Giesy	AAI	4/10/96	1415
Received by	[signature]	R [illegible]	SGA	4/10/96	1415
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

Alpha Analytical, Inc.
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2505 Chandler Avenue, Suite 1
Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-7289
Attn: Al Pollock

Sampled: 04/09/96 Received: 04/10/96 Analyzed: 04/14/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene, Toluene, Ethylbenzene, Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW2-1.5-2.0 /BMI041096-03	TPH (Purgeable)	930	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	1,100	100	ug/Kg
	Total Xylenes	6,100	100	ug/Kg
RM1-VW2-3.5-4.0 /BMI041096-04	TPH (Purgeable)	630	20	mg/Kg
	Benzene	ND	40	ug/Kg
	Toluene	ND	40	ug/Kg
	Ethylbenzene	400	40	ug/Kg
	Total Xylenes	1,400	40	ug/Kg
RM1-VW2-4.5-5.0 /BMI041096-05	TPH (Purgeable)	490	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	410	100	ug/Kg
RM1-VW2-5.5-6.0 /BMI041096-06	TPH (Purgeable)	120	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	41	20	ug/Kg

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(702) 498-3312
FAX: 702-736-7523
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Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW2-6.5-7.0 /BMI041096-07	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-7.5-8.0 /BMI041096-08	TPH (Purgeable)	990	100	mg/Kg
	Benzene	ND	200	ug/Kg
	Toluene	ND	200	ug/Kg
	Ethylbenzene	520	200	ug/Kg
	Total Xylenes	1,900	200	ug/Kg
RM1-VW2-8.5-9.0 /BMI041096-09	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-9.5-10.0 /BMI041096-10	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-10.5-11.0 /BMI041096-11	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-11.5-12.0 /BMI041096-12	TPH (Purgeable)	32	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-12.5-13.0 /BMI041096-13	TPH (Purgeable)	100	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	36	20	ug/Kg
	Total Xylenes	110	20	ug/Kg

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1-800-283-1183

Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW2-13.5-14.0 /BMI041096-14	TPH (Purgeable)	100	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	35	20	ug/Kg
	Total Xylenes	100	20	ug/Kg
RM1-VW2-14.5-15.0 /BMI041096-15	TPH (Purgeable)	170	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	86	20	ug/Kg
	Total Xylenes	210	20	ug/Kg
RM1-VW2-15.5-16.0 /BMI041096-16	TPH (Purgeable)	140	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	73	20	ug/Kg
	Total Xylenes	190	20	ug/Kg
RM1-VW2-16.5-17.0 /BMI041096-17	TPH (Purgeable)	520	20	mg/Kg
	Benzene	ND	40	ug/Kg
	Toluene	ND	40	ug/Kg
	Ethylbenzene	460	40	ug/Kg
	Total Xylenes	1,100	40	ug/Kg
RM1-VW2-17.5-18.0 /BMI041096-18	TPH (Purgeable)	440	20	mg/Kg
	Benzene	ND	40	ug/Kg
	Toluene	ND	40	ug/Kg
	Ethylbenzene	260	40	ug/Kg
	Total Xylenes	580	40	ug/Kg
RM1-VW2-18.5-19.0 /BMI041096-19	TPH (Purgeable)	320	20	mg/Kg
	Benzene	ND	40	ug/Kg
	Toluene	ND	40	ug/Kg
	Ethylbenzene	130	40	ug/Kg
	Total Xylenes	270	40	ug/Kg
RM1-VW2-19.5-20.0 /BMI041096-20	TPH (Purgeable)	190	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	32	20	ug/Kg
	Total Xylenes	56	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW2-20.5-21.0 /BMI041096-21	TPH (Purgeable)	510	100	mg/Kg
	Benzene	ND	200	ug/Kg
	Toluene	ND	200	ug/Kg
	Ethylbenzene	ND	200	ug/Kg
	Total Xylenes	ND	200	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 4/18/96
Roger L. Scholl, Ph.D.
Laboratory Director

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle

P.O. #: G002737-01

Address:

Phone #:

City, State, Zip:

Report Attention: Al Pollock

Sampled by: GERMANY

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH/G	BTXE	Remarks
	4/9	SO	BMI041096-03	RMI-VW2-1.5-2.0	1	X	X	Brass Tubes
			04	RMI-VW2-3.5-4.0	1	X	X	
			05	RMI-VW2-4.5-5.0	1	X	X	
			06	RMI-VW2-5.5-6.0	1	X	X	
			07	RMI-VW2-6.5-7.0	1	X	X	
			08	RMI-VW2-7.5-8.0	1	X	X	
			09	RMI-VW2-8.5-9.0	1	X	X	
			10	RMI-VW2-9.5-10.0	1	X	X	
			11	RMI-VW2-10.5-11.0	1	X	X	
			12	RMI-VW2-11.5-12.0	1	X	X	
			13	RMI-VW2-12.5-13.0	1	X	X	
			14	RMI-VW2-13.5-14.0	1	X	X	
			15	RMI-VW2-14.5-15.0	1	X	X	
			16	RMI-VW2-15.5-16.0	1	X	X	
			17	RMI-VW2-16.5-17.0	1	X	X	
			18	RMI-VW2-17.5-18.0	1	X	X	

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/10/96	1030
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Page # 2 of 2

Client Name: Battelle

P.O. # 6002737-01

Address:

Phone #:

City, State, Zip:

Report Attention: Al Pollock

Sampled by: Germany

Analyses Required

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH	BTEX								Remarks
	4/9	SO	BMI-041096-19	RMI-VW2-18.5-19.0	1	X	X								
	✓	✓	20	RMI-VW2-19.5-20.0	1	X	X								
	✓	✓	21	RMI-VW2-20.5-21.0	1	X	X								

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	[illegible]	Linda Bydairk	AAI	4/10/96	1030
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 2/2

Proj. No. G002737-01

Project Title: Rhein-Main AB, POL Yard

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
✓ 4.9.96	~~10~~ 11[29]	RMI-VWZ-19.5-20.0	✓	✓		1	Brass sleeve
✓ 4.9.96	11[47]	RMI-VWZ-20.5-21.0	✓	✓		"	" "

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	4.9.96 13[15]				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		[signature]	4/10/96 1030	

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 1/2

Proj. No. G002737-01

Project Title Rhein-Main AB, POL Yard

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
✓4.9.96	0750	RM1-VW2-1.5-2.0	✓	✓		1	Brass sleeve
✓4.9.96	0810	RM1-VW2-3.5-4.0	✓	✓		"	" "
✓4.9.96	0810	RM1-VW2-4.5-5.0	✓	✓		"	" "
✓4.9.96	0829	RM1-VW2-5.5-6.0	✓	✓		"	" "
✓4.9.96	0829	RM1-VW2-6.5-7.0	✓	✓		"	" "
✓4.9.96	0847	RM1-VW2-7.5-8.0	✓	✓		"	" "
✓4.9.96	0847	RM1-VW2-8.5-9.0	✓	✓		"	" "
✓4.9.96	0903	RM1-VW2-9.5-10.0	✓	✓		"	" "
✓4.9.96	0903	RM1-VW2-10.5-11.0	✓	✓		"	" "
✓4.9.96	0921	RM1-VW2-11.5-12.0	✓	✓		"	" "
✓4.9.96	0921	RM1-VW2-12.5-13.0	✓	✓		"	" "
✓4.9.96	1002	RM1-VW2-13.5-14.0	✓	✓		"	" "
✓4.9.96	1002	RM1-VW2-14.5-15.0	✓	✓		"	" "
✓4.9.96	1014	RM1-VW2-15.5-16.0	✓	✓		"	" "
✓4.9.96	1014	RM1-VW2-16.5-17.0	✓	✓		"	" "
✓4.9.96	1042	RM1-VW2-17.5-18.0	✓	✓		"	" "
✓4.9.96	1042	RM1-VW2-18.5-19.0	✓	✓		"	" "

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	4.9.96 1315				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		[illegible]	4/10/96 1030	

Alpha Analytical, Inc.
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(702) 498-3312
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1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-6199
Attn: Al Pollack

Sampled: 04/09-10/96   Received: 04/12/96   Analyzed: 04/17-18/96

Matrix: [X] Soil   [ ] Water   [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene, Toluene, Ethylbenzene, Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW2-22.3-22.8 /BMI041296-17	TPH (Purgeable)	230	10	mg/Kg
	Benzene	250	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	200	20	ug/Kg
	Total Xylenes	460	20	ug/Kg
RM1-VW2-23.3-23.8 /BMI041296-18	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	170	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	24	20	ug/Kg
RM1-VW2-24.3-24.8 /BMI041296-19	TPH (Purgeable)	92	10	mg/Kg
	Benzene	98	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	44	20	ug/Kg
	Total Xylenes	97	20	ug/Kg
RM1-VW2-25.3-25.8 /BMI041296-20	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	400	20	ug/Kg
	Toluene	68	20	ug/Kg
	Ethylbenzene	24	20	ug/Kg
	Total Xylenes	30	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-VW2-27.3-27.8	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-21	Benzene	900	20	ug/Kg
	Toluene	390	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	36	20	ug/Kg
RM1-VW2-27.8-28.3	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-22	Benzene	1,700	20	ug/Kg
	Toluene	980	20	ug/Kg
	Ethylbenzene	45	20	ug/Kg
	Total Xylenes	130	20	ug/Kg
RM1-VW2-29.3-29.8	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-23	Benzene	400	20	ug/Kg
	Toluene	39	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-29.8-30.3	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-24	Benzene	530	20	ug/Kg
	Toluene	28	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-31.3-31.8	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-25	Benzene	240	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-VW2-31.8-32.3	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-26	Benzene	300	20	ug/Kg
	Toluene	230	20	ug/Kg
	Ethylbenzene	55	20	ug/Kg
	Total Xylenes	140	20	ug/Kg
RM1-MW1-2.0-2.5	TPH (Purgeable)	2,500	250	mg/Kg
/BMI041296-27	Benzene	ND	500	ug/Kg
	Toluene	ND	500	ug/Kg
	Ethylbenzene	ND	500	ug/Kg
	Total Xylenes	4,800	500	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-MW1-3.5-4.0 /BMI041296-28	TPH (Purgeable)	19	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-4.0-4.5 /BMI041296-29	TPH (Purgeable)	69	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-5.5-6.0 /BMI041296-30	TPH (Purgeable)	640	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	ND	100	ug/Kg
RM1-MW1-6.5-7.0 /BMI041296-31	TPH (Purgeable)	49	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-7.5-8.0 /BMI041296-32	TPH (Purgeable)	100	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-8.5-9.0 /BMI041296-33	TPH (Purgeable)	10	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-9.5-10.0 /BMI041296-34	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-MW1-10.5-11.0 /BMI041296-35	TPH (Purgeable)	110	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-2.5-3.0 /BMI041296-36	TPH (Purgeable)	3,100	500	mg/Kg
	Benzene	ND	1,000	ug/Kg
	Toluene	ND	1,000	ug/Kg
	Ethylbenzene	ND	1,000	ug/Kg
	Total Xylenes	3,200	1,000	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 4/23/96
Roger L. Scholl, Ph.D.
Laboratory Director

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No. G002737-01

Project Title Rhein-Main AB, POL Yard

SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240			Container No.	Number of Containers	Remarks
√4.9.96	1345	RMI-VW2-22.3-22.8	√	√				1	Brass sleeve
√4.9.96	1345	RMI-VW2-23.3-23.8	√	√				"	" "
√4.9.96	1420	RMI-VW2-24.3-24.8	√	√				"	" "
√4.9.96	1420	RMI-VW2-25.3-~~25.8~~ 25.8	√	√	X	X		"	" "
√4.9.96	1445	RMI-VW2-27.3-27.8	√	√				"	" "
√4.9.96	1450	RMI-VW2-27.8-28.3	√	√				"	" "
√4.10.96	0830	RMI-VW2-29.3-29.8	√	√				"	" "
√4.10.96	0830	RMI-VW2-29.8-30.3	√	√				"	" "
√4.10.96	0909	RMI-VW2-31.3-31.8	√	√				"	" "
√4.10.96	0909	RMI-VW2-31.8-32.3	√	√				"	" "
√4.10.96	1350	RMI-MW1-2.0-2.5	√	√				"	" "
√4.10.96	1350	RMI-MW1-2.5-3.0	√	√				"	" "
√4.10.96	1415	RMI-MW1-3.5-4.0	√	√				"	" "
√4.10.96	1415	RMI-MW1-4.0-4.5	√	√				"	" "
√4.10.96	1425	RMI-MW1-5.5-6.0	√	√					
√4.10.96	1425	RMI-MW1-6.5-7.0	√	√					

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
T Kramer	4.10.96 1545				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	4/12/96 1000		

1 . 7

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ____________

Proj. No.	Project Title
G00273701	Rhein-Main AB, POL Yard

SAMPLERS: (Signature) C. Perry, W. Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
✓ 4.10.96	1442	RMI-MWI-7.5-8.0	✓	✓		1	Brass sleeve
✓ 4.10.96	1445	RMI-MWI-8.5-9.0	✓	✓		"	" "
✓ 4.10.96	1512	RMI-MWI-9.5-10.0	✓	✓		"	"
✓ 4.10.96	1512	RMI-MWI-10.5-11.0	✓	✓		"	"
						"	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
J. Kramer	4.10.96 1545				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[illegible]	4/12/96 1000		

Alpha Analytical, Inc.

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Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Billing Information:

Name

Address

City, State, Zip

Phone Number

Client Name: Battelle

Address

City, State, Zip

P.O. # 6002737-01

Phone #

Report Attention: Al Pollock

Sampled by: JEKMAN

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPHG	BTEX							Remarks
	4/9	SO	BMI041296-17	RMI-VW2-22.3-22.8	1	X	X							
			18	RMI-VW2-23.3-23.8	1	X	X							
			19	RMI-VW2-24.3-24.8	1	X	X							
			20	RMI-VW2-25.3-25.8	1	X	X							
			21	RMI-VW2-27.3-27.8	1	X	X							
			22	RMI-VW2-27.8-28.3	1	X	X							
	4/10		23	RMI-VW2-29.3-29.8	1	X	X							
			24	RMI-VW2-29.8-30.3	1	X	X							
			25	RMI-VW2-31.3-31.8	1	X	X							
			26	RMI-VW2-31.8-32.3	1	X	X							
			27	RMI-MW1-2.0-2.5	1	X	X							
			28	RMI-MW1-3.5-4.0	1	X	X							
			29	RMI-MW1-4.0-4.5	1	X	X							
			30	RMI-MW1-5.5-6.0	1	X	X							
			31	RMI-MW1-6.5-7.0	1	X	X							
			32	RMI-MW1-7.5-8.0	1	X	X							

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/12/96	1000
Relinquished by					
Received by					
Relinquished by					
Received by				—	

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other

Billing Information:

Name

Address

City, State, Zip

Phone Number

Alpha Analytical, Inc.
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Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle

P.O. #

Address

Phone #

City, State, Zip

Report Attention: Al Pollack

Sampled by: GERMANY

Analyses Required: TPHG, BTXE

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPHG	BTXE	Remarks
	4/10	SO	BMI041296-33	RMI-MW1-8.5-9.0	1	X	X	Bmb
	✓	✓	34	RMI-MW1-9.5-10.0	1	X	X	
	✓	✓	35	RMI-MW1-10.5-11.0	1	X	X	
	✓	✓	36	RMI-MW1-2.5-3.0	1	X	X	

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	L. Bydairk	Linda Bydairk	AAI	4/12/96	1000
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

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1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 04/10-11/96 Received: 04/12/96 Analyzed: 04/16-17/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-MW1-11.5-12.0	TPH (Purgeable)	190	10	mg/Kg
/BMI041296-01	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-12.5-13.0	TPH (Purgeable)	16	10	mg/Kg
/BMI041296-02	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-13.5-14.0	TPH (Purgeable)	45	10	mg/Kg
/BMI041296-03	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-14.5-15.0	TPH (Purgeable)	96	10	mg/Kg
/BMI041296-04	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-MW1-16.5-17.0	TPH (Purgeable)	35	10	mg/Kg
/BMI041296-05	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-18.0-18.5	TPH (Purgeable)	19	10	mg/Kg
/BMI041296-06	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-15.5-16.0	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-07	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-18.5-19.0	TPH (Purgeable)	33	10	mg/Kg
/BMI041296-08	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-19.0-19.5	TPH (Purgeable)	130	50	mg/Kg
/BMI041296-09	Benzene	510	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	ND	100	ug/Kg
RM1-MW1-19.5-20.0	TPH (Purgeable)	91	50	mg/Kg
/BMI041296-10	Benzene	540	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	ND	100	ug/Kg
RM1-MW1-22.0-22.5	TPH (Purgeable)	540	50	mg/Kg
/BMI041296-11	Benzene	1,000	100	ug/Kg
	Toluene	120	100	ug/Kg
	Ethylbenzene	2,900	100	ug/Kg
	Total Xylenes	13,000	100	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-MW1-22.5-23.0	TPH (Purgeable)	14	10	mg/Kg
/BMI041296-12	Benzene	300	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	100	20	ug/Kg
	Total Xylenes	470	20	ug/Kg
RM1-MW1-24.0-24.5	TPH (Purgeable)	12	10	mg/Kg
/BMI041296-13	Benzene	100	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	65	20	ug/Kg
	Total Xylenes	310	20	ug/Kg
RM1-MW1-24.5-25.0	TPH (Purgeable)	14	10	mg/Kg
/BMI041296-14	Benzene	34	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	30	20	ug/Kg
	Total Xylenes	120	20	ug/Kg
RM1-MW1-26.0-26.5	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-15	Benzene	110	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-MW1-26.5-27.0	TPH (Purgeable)	ND	10	mg/Kg
/BMI041296-16	Benzene	220	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	52	20	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 4/23/96
Roger L. Scholl, Ph.D.
Laboratory Director

Billing Information:
Name
Address
City, State, Zip
Phone Number

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255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name: Battelle
P.O. # 0002737-01
Address
Phone #
City, State, Zip
Report Attention: U Pollock
Sampled by: GERMANY

Time Sampled	Date Sampled	Type* See Key Below	Lab ID Number	Sample Description	Number of Containers	TPH/G	BTEX	Remarks
	4/10	30	BMI041296-01	RMI-MW1-11.5-12.0	1	X	X	Brass tubes
	✓	↓	02	RMI-MW1-12.5-13.0	1	X	X	
	✓	↓	03	RMI-MW1-13.5-14.0	1	X	X	
	✓	↓	04	RMI-MW1-14.5-15.0	1	X	X	
	4/11	↓	05	RMI-MW1-16.5-17.0	1	X	X	
	↓	↓	06	RMI-MW1-18.0-18.5	1	X	X	
	↓	↓	07	RMI-MW1-15.5-16.0	1	X	X	
	↓	↓	08	RMI-MW1-18.5-19.0	1	X	X	
	↓	↓	09	RMI-MW1-19.0-19.5	1	X	X	
	↓	↓	10	RMI-MW1-19.5-20.0	1	X	X	
	↓	↓	11	RMI-MW1-22.0-22.5	1	X	X	
	↓	↓	12	RMI-MW1-22.5-23.0	1	X	X	
	↓	↓	13	RMI-MW1-24.0-24.5	1	X	X	
	↓	↓	14	RMI-MW1-24.5-25.0	1	X	X	
	↓	↓	15	RMI-MW1-26.0-26.5	1	X	X	
	↓	↓	16	RMI-MW1-26.5-27.0	1	X	X	

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bydairk	Linda Bydairk	AAI	4/12/96	1000
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

Alpha Analytical, Inc.
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Las Vegas, Nevada 89120
(702) 498-3312
FAX: 702-736-7523
1-800-283-1183

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-3753
Attn: Al Pollock

Sampled: 07/25/96 Received: 07/29/96 Analyzed: 08/03-07/96

Matrix: [X] Soil [ ] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated As Gasoline
BTEX - Benzene,Toluene,Ethylbenzene,Xylenes

Methodology: TPH - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-HSP-0-15 /BMI072996-01	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	37	20	ug/Kg
RM1-HSP-30-60 /BMI072996-02	TPH (Purgeable)	3,700	500	mg/Kg
	Benzene	ND	1,000	ug/Kg
	Toluene	ND	1,000	ug/Kg
	Ethylbenzene	7,100	1,000	ug/Kg
	Total Xylenes	47,000	1,000	ug/Kg
RM1-HSP-60-75 /BMI072996-03	TPH (Purgeable)	420	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	730	100	ug/Kg
RM1-HSP-90-1.05 /BMI072996-04	TPH (Purgeable)	93	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	84	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-HSP-1.2-1.35 /BMI072996-05	TPH (Purgeable)	190	20	mg/Kg
	Benzene	ND	40	ug/Kg
	Toluene	ND	40	ug/Kg
	Ethylbenzene	ND	40	ug/Kg
	Total Xylenes	83	40	ug/Kg
RM1-HSP-1.5-1.65 /BMI072996-06	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-1.8-1.95 /BMI072996-07	TPH (Purgeable)	92	20	mg/Kg
	Benzene	ND	40	ug/Kg
	Toluene	ND	40	ug/Kg
	Ethylbenzene	ND	40	ug/Kg
	Total Xylenes	ND	40	ug/Kg
RM1-HSP-2.1-2.25 /BMI072996-08	TPH (Purgeable)	260	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	890	100	ug/Kg
RM1-HSP-2.4-2.55 /BMI072996-09	TPH (Purgeable)	230	50	mg/Kg
	Benzene	ND	100	ug/Kg
	Toluene	ND	100	ug/Kg
	Ethylbenzene	ND	100	ug/Kg
	Total Xylenes	270	100	ug/Kg
RM1-HSP-2.7-2.85 /BMI072996-10	TPH (Purgeable)	16	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-3.15-3.30 /BMI072996-11	TPH (Purgeable)	120	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-3.3-3.45 /BMI072996-12	TPH (Purgeable)	110	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-HSP-3.6-3.75 /BMI072996-13	TPH (Purgeable)	260	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	140	20	ug/Kg
RM1-HSP-3.9-4.05 /BMI072996-14	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-4.2-4.35 /BMI072996-15	TPH (Purgeable)	300	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	97	20	ug/Kg
	Total Xylenes	920	20	ug/Kg
RM1-HSP-4.5-4.65 /BMI072996-16	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-4.95-5.10 /BMI072996-17	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-5.1-5.25 /BMI072996-18	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-5.4-5.55 /BMI072996-19	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RM1-HSP-5.7-5.85 /BMI072996-20	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-6.0-6.15 /BMI072996-21	TPH (Purgeable)	ND	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-6.3-6.45 /BMI072996-22	TPH (Purgeable)	40	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg
RM1-HSP-6.6-6.75 /BMI072996-23	TPH (Purgeable)	49	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	41	20	ug/Kg
RM1-HSP-6.9-7.05 /BMI072996-24	TPH (Purgeable)	61	10	mg/Kg
	Benzene	ND	20	ug/Kg
	Toluene	ND	20	ug/Kg
	Ethylbenzene	ND	20	ug/Kg
	Total Xylenes	ND	20	ug/Kg

ND - Not Detected

Approved by: Roger L. Scholl Date: 8/14/96

Roger L. Scholl, Ph.D.
Laboratory Director

Billing Information:
Name
Address
City, State, Zip
Phone Number Fax

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Page # 2 of 2

Client Name Battelle	P.O. #	Job # 600 2737-01	
Address	PWS #	DWR #	
City, State, Zip	Phone #	Fax #	

Analyses Required

Time Sampled	Date Sampled	Matrix* See Key Below	Office Use Only Sampled by / Lab ID Number	Report Attention C. Pollack / Sample Description		Total and type of containers ** See below	TPHg	BTXE
	7/25	SO	BMI 072M6-13	BMI-HSP-	3.6-3.75	1B	X	X
			14	" "	3.9-4.05	"	X	X
			15	" "	4.2-4.35	"	X	X
			16	" "	4.5-4.65	"	X	X
			17	" "	4.95-5.10	"	X	X
			18	" "	5.1-5.25	"	X	X
			19	" "	5.4-5.55	"	X	X
			20	" "	5.7-5.85	"	X	X
			21	" "	6.0-6.15	"	X	X
			22	" "	6.3-6.45	"	X	X
			23	" "	6.6-6.75	"	X	X
			24	" "	6.9-7.05	"	X	X

REMARKS:
Summary

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	[signature]	Linda Dydasik	AAI	7/27/??	0730
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Oil

Billing Information:

Name

Address

City, State, Zip

Phone Number Fax

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431
Phone (702) 355-1044
Fax (702) 355-0406

Client Name Battelle	P.O. #	Job # G0027 37-01
Address	PWS #	DWR #
City, State, Zip	Phone # (714) 424-3353	Fax #
Sampled by? Client	Report Attention Al Pollack	

Analyses Required

Time Sampled	Date Sampled	Matrix* See Key Below	Office Use Only Lab ID Number	Sample Description	Total and type of containers ** See below	TPHg	BTXE
	7/25	SO	BMI 072996-01	RMI-HSP - 0-15	1 B	X	X
			*02	" " 30-60	1 B	X	X
			03	" " 60-75	1 B	X	X
			04	" " 90-1.05	1 B	X	X
			05	" " 1.2-1.35	1 B	X	X
			06	" " 1.5-1.65	1 B	X	X
			07	" " 1.8-1.95	1 B	X	X
			08	" " 2.1-2.25	1 B	X	X
			09	" " 2.4-2.55	1 B	X	X
			10	" " 2.7-2.85	1 B	X	X
			11	" " 3.15-3.30	1 B	X	X
			12	" " 3.3-3.45	1 B	X	X

REMARKS:

Germany Samples Actually picked up Saturday 7/27/96

* for 02 The Brass Tube reads 30-60, their COC says 30-45.

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bykwick	Linda Bykwick	AAI	7/27/96	0730
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

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Sacramento, California
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FAX: (916) 366-9138

ANALYTICAL REPORT

Battelle
505 King Ave
Columbus Ohio 43201

Job#: G002737-01
Phone: (614) 424-6199
Attn: Al Pollock

Sampled: 12/10/96 Received: 12/11/96 Analyzed: 12/13-14/96

Matrix: [ ] Soil [X] Water [ ] Waste

Analysis Requested: TPH - Total Petroleum Hydrocarbons-Purgeable Quantitated as Gasoline
TPH - Total Petroleum Hydrocarbons-Extractable Quantitated as Diesel
BTEX - Benzene, Toluene, Ethylbenzene, Xylenes

Methodology: TPH (Gas) - Modified 8015/DHS LUFT Manual/BLS-191
TPH (Diesel) - Modified 8015/DHS LUFT Manual/BLS-191
BTEX - Method 624/8240

Results:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RMAB-MWI /BMI121196-01	TPH (Gasoline)	24	5.0	mg/L
	TPH (Diesel)*	5.1	0.50	mg/L
	Benzene	9,100	10	ug/L
	Toluene	6,600	10	ug/L
	Ethylbenzene	820	10	ug/L
	Total Xylenes	2,800	10	ug/L
RMAB-MWII /BMI121196-02	TPH (Gasoline)	60	25	mg/L
	TPH (Diesel)	4.0	0.50	mg/L
	Benzene	30,000	50	ug/L
	Toluene	30,000	50	ug/L
	Ethylbenzene	720	50	ug/L
	Total Xylenes	2,500	50	ug/L

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Continued:

Client ID/ Lab ID	Parameter	Concentration	Detection Limit	
RMAB-MWIII /BMI121196-03	TPH (Gasoline)	20	5.0	mg/L
	TPH (Diesel)	3.5	0.50	mg/L
	Benzene	7,300	10	ug/L
	Toluene	3,900	10	ug/L
	Ethylbenzene	820	10	ug/L
	Total Xylenes	3,000	10	ug/L

* - Components are primarily in the range of gasoline with minor amounts of diesel, light oil and motor oil.

Note: Hydrocarbons outside the range of diesel may have varying recoveries.

ND - Not Detected

Approved by: Roger L. Scholl Date: 12/20/96
Roger L. Scholl, Ph.D.
Laboratory Director

Billing Information:

Name

Address

City, State, Zip

Phone Number Fax

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Client Name Dattille	P.O. #	Job # 6002737-01
Address	PWS #	DWR #
City, State, Zip	Phone #	Fax #

Sampled by GERMANY

Report Attention

Time Sampled	Date Sampled	Matrix* See Key Below	Office Use Only Lab ID Number	Sample Description	Total and type of containers ** See below	TPH	TPHg	BTXE
	12/10	AR	BMI121196-01	RMAB-MW I	5	x	x	x
	✓	✓	02	RMAB-MW II	5	x	x	x
	✓	✓	03	RMAB-MW III	5	x	x	x

Analyses Required

REMARKS:

GERMANY

	Signature	Print Name	Company	Date	Time
Relinquished by					
Received by	Linda Bykcik	Linda Bykcik	AAI	12/11/96	1100
Relinquished by					
Received by					
Relinquished by					
Received by					

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.

*Key: AQ - Aqueous SO - Soil WA - Waste OT - Other **: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar

Battelle
Columbus Laboratories

TO ALPHA ANALYTICAL
255 GLENDALE SUITE 21
SPARKS, NEVADA 89431

CHAIN OF CUSTODY RECORD

Form No. 1/1

Proj. No.	Project Title
6002737-01	RHEIN-MAIN AB. POL YARD

SAMPLERS: (Signature) W. A. SIEBENLIST W. A. Siebenlist

DATE	TIME	SAMPLE I.D.	TPH-DIESEL 8015M	BTEX/TPH-GAS 8015/8240	Container No.	Number of Containers	Remarks
12-10-96	08:30	RMAB-MWI-1		X			
12-10-96	08:35	RMAB-MWI-2		X			
12-10-96	08:40	RMAB-MWI-3		X			
12-10-96	08:50	RMAB-MWI-4	X				
12-10-96	08:55	RMAB-MWI-5	X				
12-10-96	10:05	RMAB-MWII-1		X			
12-10-96	10:10	RMAB-MWII-2		X			
12-10-96	10:15	RMAB-MWII-3		X			
12-10-96	10:30	RMAB-MWII-4	X				
12-10-96	10:40	RMAB-MWII-5	X				
12-10-96	11:25	RMAB-MWIII-1		X			
12-10-96	11:30	RMAB-MWIII-2		X			
12-10-96	11:35	RMAB-MWIII-3		X			
12-10-96	11:50	RMAB-MWIII-4	X				
12-10-96	11:55	RMAB-MWIII-5	X				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
W. Siebenlist	12-10-96 13:00				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		[signature]	12/11/96 1100		

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FAX: (916) 366-9138

ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: Rhein-Main AB
Phone: (614) 424-3779
Attn: Julie Kramer

Methodology: TPHP - Modified 8015/DHS LUFT Manual - Purgeable
VOCs - Method 8260

	Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID : **GP-14**	TPH Purgeable	0.56	0.25 mg/L	9/23/98	10/1/98
Lab ID : 98092643-01A	Benzene	8.3	1.0 µg/L	9/23/98	10/1/98
	Toluene	ND	1.0 µg/L	9/23/98	10/1/98
	Ethylbenzene	2.4	1.0 µg/L	9/23/98	10/1/98
	m,p-Xylene	1.0	1.0 µg/L	9/23/98	10/1/98
	o-Xylene	1.2	1.0 µg/L	9/23/98	10/1/98
Client ID : **GP-10A**	TPH Purgeable	5.9	0.25 mg/L	9/23/98	10/1/98
Lab ID : 98092643-02A	Benzene	780	1.0 µg/L	9/23/98	10/1/98
	Toluene	77	1.0 µg/L	9/23/98	10/1/98
	Ethylbenzene	310	1.0 µg/L	9/23/98	10/1/98
	m,p-Xylene	170	1.0 µg/L	9/23/98	10/1/98
	o-Xylene	48	1.0 µg/L	9/23/98	10/1/98
Client ID : **GP-9**	TPH Purgeable	ND	0.050 mg/L	9/23/98	10/1/98
Lab ID : 98092643-03A	Benzene	ND	0.50 µg/L	9/23/98	10/1/98
	Toluene	ND	0.50 µg/L	9/23/98	10/1/98
	Ethylbenzene	ND	0.50 µg/L	9/23/98	10/1/98
	m,p-Xylene	ND	0.50 µg/L	9/23/98	10/1/98
	o-Xylene	ND	0.50 µg/L	9/23/98	10/1/98
Client ID : **GP-1**	TPH Purgeable	2.0	0.25 mg/L	9/22/98	10/1/98
Lab ID : 98092643-04A	Benzene	3.1	1.0 µg/L	9/22/98	10/1/98
	Toluene	ND	1.0 µg/L	9/22/98	10/1/98
	Ethylbenzene	2.0	1.0 µg/L	9/22/98	10/1/98
	m,p-Xylene	9.9	1.0 µg/L	9/22/98	10/1/98
	o-Xylene	1.9	1.0 µg/L	9/22/98	10/1/98
Client ID : **GP-5**	TPH Purgeable	3.2	0.050 mg/L	9/22/98	10/1/98
Lab ID : 98092643-05A	Benzene	12	0.50 µg/L	9/22/98	10/1/98
	Toluene	1.4	0.50 µg/L	9/22/98	10/1/98
	Ethylbenzene	260	0.50 µg/L	9/22/98	10/1/98
	m,p-Xylene	280	0.50 µg/L	9/22/98	10/1/98
	o-Xylene	5.1	0.50 µg/L	9/22/98	10/1/98

Alpha Analytical, Inc.
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FAX: (916) 366-9138

Client ID :	**GP-3**	TPH Purgeable	6.8	0.10 mg/L	9/22/98	10/1/98
Lab ID :	98092643-06A	Benzene	450	0.50 µg/L	9/22/98	10/1/98
		Toluene	ND	0.50 µg/L	9/22/98	10/1/98
		Ethylbenzene	390	0.50 µg/L	9/22/98	10/1/98
		m,p-Xylene	1200	0.50 µg/L	9/22/98	10/1/98
		o-Xylene	6.7	0.50 µg/L	9/22/98	10/1/98
Client ID :	**GP-10**	TPH Purgeable	0.15	0.050 mg/L	9/23/98	10/1/98
Lab ID :	98092643-07A	Benzene	76	0.50 µg/L	9/23/98	10/1/98
		Toluene	ND	0.50 µg/L	9/23/98	10/1/98
		Ethylbenzene	ND	0.50 µg/L	9/23/98	10/1/98
		m,p-Xylene	ND	0.50 µg/L	9/23/98	10/1/98
		o-Xylene	ND	0.50 µg/L	9/23/98	10/1/98
Client ID :	**GP-2**	TPH Purgeable	9.8	2.5 mg/L	9/24/98	10/1/98
Lab ID :	98092643-08A	Benzene	240	10 µg/L	9/24/98	10/1/98
		Toluene	11	10 µg/L	9/24/98	10/1/98
		Ethylbenzene	650	10 µg/L	9/24/98	10/1/98
		m,p-Xylene	2300	10 µg/L	9/24/98	10/1/98
		o-Xylene	48	10 µg/L	9/24/98	10/1/98
Client ID :	**GP-4**	TPH Purgeable	0.6	0.050 mg/L	9/24/98	10/1/98
Lab ID :	98092643-09A	Benzene	40	0.50 µg/L	9/24/98	10/1/98
		Toluene	ND	0.50 µg/L	9/24/98	10/1/98
		Ethylbenzene	ND	0.50 µg/L	9/24/98	10/1/98
		m,p-Xylene	ND	0.50 µg/L	9/24/98	10/1/98
		o-Xylene	ND	0.50 µg/L	9/24/98	10/1/98

ND = Not Detected

Approved By: Roger Scholl

Roger L. Scholl, Ph.D.
Laboratory Director

Date: 10/5/98

BMI 4809264 3-0

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No. G002737-01

Project Title Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, Chris Perry

	DATE	TIME	SAMPLE I.D.	TPH - 8015 Mod.	BTEX - 624/8021 Mod.	Container No.	Number of Containers	Remarks
-01	9.23.98	11:00	GP-14	X	X	VOA	2	HCl
-02	9.23.98	10:40	GP-10A	X	X	"	"	HCl
-03	9.23.98	12:15	GP-9	X	X	"	"	HCl
-04	9.22.98	15:40	GP-1	X	X	"	"	HCl
-05	9.22.98	17:40	GP-5	X	X	"	"	HCl
-06	9.22.98	14:20	GP-3	X	X	"	"	HCl
-07	9.23.98	16:40	GP-10	X	X	"	"	HCl
-08	9.24.98	10:00	GP-2	X	X	"	"	HCl
-09	9.24.98	11:20	GP-4	X	X	"	"	HCl

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	9.24.98 ~~23~~ 13:00 ~~17:00~~	Susanne Mills 9/26 11:00			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

Page 1 of 1

Billing Information :
Battelle
505 King Avenue

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98092643

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job : Rhein-Main AB
PO :
QC Level :

Sampled by :

Cooler Temp : °C

Report Attention : Julie Kramer

28-Sep-98 9/26

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_W	TPH/P_W								Sample Remarks
BMI98092643-01	GP-14	AQ	9/23/98	2	10		A	A								
BMI98092643-02	GP-10A	AQ	9/23/98	2	10		A	A								
BMI98092643-03	GP-9	AQ	9/23/98	2	10		A	A								
BMI98092643-04	GP-1	AQ	9/22/98	2	10		A	A								
BMI98092643-05	GP-5	AQ	9/22/98	2	10		A	A								
BMI98092643-06	GP-3	AQ	9/22/98	2	10		A	A								
BMI98092643-07	GP-10	AQ	9/23/98	2	10		A	A								
BMI98092643-08	GP-2	AQ	9/24/98	2	10		A	A								
BMI98092643-09	GP-4	AQ	9/24/98	2	10		A	A								

Comments: FOREIGN SOILS. CA DETECTION LIMITS

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Suzanne Miller	S. Miller	AAI	9/26/98
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

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Sacramento, California
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FAX: (916) 366-9138

ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: G002737-01
Phone: (614) 424-3779
Attn: Julie Kramer

Methodology: TPHP - Modified 8015/DHS LUFT Manual - Purgeable
VOCs - Method 8260

	Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID : **GP-16**	TPH Purgeable	0.14	0.050 mg/L	9/25/98	10/6/98
Lab ID : 98092922-01A	Benzene	6.5	0.50 µg/L	9/25/98	10/6/98
	Toluene	ND	0.50 µg/L	9/25/98	10/6/98
	Ethylbenzene	4.4	0.50 µg/L	9/25/98	10/6/98
	m,p-Xylene	1.9	0.50 µg/L	9/25/98	10/6/98
	o-Xylene	1.8	0.50 µg/L	9/25/98	10/6/98
Client ID : **GP-17**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/6/98
Lab ID : 98092922-02A	Benzene	1.6	0.50 µg/L	9/28/98	10/6/98
	Toluene	ND	0.50 µg/L	9/28/98	10/6/98
	Ethylbenzene	0.78	0.50 µg/L	9/28/98	10/6/98
	m,p-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
	o-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
Client ID : **GP-8**	TPH Purgeable	ND	0.050 mg/L	9/25/98	10/6/98
Lab ID : 98092922-03A	Benzene	7.1	0.50 µg/L	9/25/98	10/6/98
	Toluene	ND	0.50 µg/L	9/25/98	10/6/98
	Ethylbenzene	ND	0.50 µg/L	9/25/98	10/6/98
	m,p-Xylene	ND	0.50 µg/L	9/25/98	10/6/98
	o-Xylene	ND	0.50 µg/L	9/25/98	10/6/98
Client ID : **GP-9C**	TPH Purgeable	0.18	0.050 mg/L	9/24/98	10/6/98
Lab ID : 98092922-04A	Benzene	ND	0.50 µg/L	9/24/98	10/6/98
	Toluene	ND	0.50 µg/L	9/24/98	10/6/98
	Ethylbenzene	ND	0.50 µg/L	9/24/98	10/6/98
	m,p-Xylene	ND	0.50 µg/L	9/24/98	10/6/98
	o-Xylene	ND	0.50 µg/L	9/24/98	10/6/98
Client ID : **GP-6**	TPH Purgeable	0.13	0.050 mg/L	9/24/98	10/6/98
Lab ID : 98092922-05A	Benzene	ND	0.50 µg/L	9/24/98	10/6/98
	Toluene	ND	0.50 µg/L	9/24/98	10/6/98
	Ethylbenzene	ND	0.50 µg/L	9/24/98	10/6/98
	m,p-Xylene	ND	0.50 µg/L	9/24/98	10/6/98
	o-Xylene	ND	0.50 µg/L	9/24/98	10/6/98

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Client ID :	**GP-9B**	TPH Purgeable	ND	0.050 mg/L	9/25/98	10/6/98
Lab ID :	98092922-06A	Benzene	ND	0.50 µg/L	9/25/98	10/6/98
		Toluene	ND	0.50 µg/L	9/25/98	10/6/98
		Ethylbenzene	ND	0.50 µg/L	9/25/98	10/6/98
		m,p-Xylene	ND	0.50 µg/L	9/25/98	10/6/98
		o-Xylene	ND	0.50 µg/L	9/25/98	10/6/98
Client ID :	**GP-15**	TPH Purgeable	ND	0.050 mg/L	9/25/98	10/6/98
Lab ID :	98092922-07A	Benzene	ND	0.50 µg/L	9/25/98	10/6/98
		Toluene	ND	0.50 µg/L	9/25/98	10/6/98
		Ethylbenzene	ND	0.50 µg/L	9/25/98	10/6/98
		m,p-Xylene	ND	0.50 µg/L	9/25/98	10/6/98
		o-Xylene	ND	0.50 µg/L	9/25/98	10/6/98
Client ID :	**GP-20**	TPH Purgeable	0.074	0.050 mg/L	9/28/98	10/6/98
Lab ID :	98092922-08A	Benzene	ND	0.50 µg/L	9/28/98	10/6/98
		Toluene	ND	0.50 µg/L	9/28/98	10/6/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/6/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
Client ID :	**GP-21**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/6/98
Lab ID :	98092922-09A	Benzene	ND	0.50 µg/L	9/28/98	10/6/98
		Toluene	ND	0.50 µg/L	9/28/98	10/6/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/6/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
Client ID :	**GP-RINSATE**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/6/98
Lab ID :	98092922-10A	Benzene	ND	0.50 µg/L	9/28/98	10/6/98
		Toluene	ND	0.50 µg/L	9/28/98	10/6/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/6/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/6/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/6/98

ND = Not Detected

Approved By: Roger Scholl

Roger L. Scholl, Ph.D.
Laboratory Director

Date: 10/8/98

CHAIN-OF-CUSTODY RECORD

Billing Information :
Battelle
505 King Avenue

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98092922

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job : G002737-01
PO :
QC Level :

Sampled by : J. Kramer, C. Perry

Cooler Temp : °C

29-Sep-98

Report Attention : Julie Kramer

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_W	TPH/P_W								Sample Remarks
BMI98092922-01	GP-16	AQ	9/25/98	2	10		A	A								
BMI98092922-02	GP-17	AQ	9/28/98	2	10		A	A								
BMI98092922-03	GP-8	AQ	9/25/98	2	10		A	A								
BMI98092922-04	GP-9C	AQ	9/24/98	2	10		A	A								
BMI98092922-05	GP-6	AQ	9/24/98	2	10		A	A								
BMI98092922-06	GP-9B	AQ	9/25/98	2	10		A	A								
BMI98092922-07	GP-15	AQ	9/25/98	2	10		A	A								
BMI98092922-08	GP-20	AQ	9/28/98	2	10		A	A								
BMI98092922-09	GP-21	AQ	9/28/98	2	10		A	A								
BMI98092922-10	GP-RINSATE	AQ	9/28/98	2	10		A	A								

Comments: THIS PROJECT IS TITLED RHEIN-MAIN AB(FOREIGN SAMPLES)

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Jill Hertzler	J. Hertzler	AAI	9/29/98 /
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Battelle
Columbus Laboratories

Form No. ______

CHAIN OF CUSTODY RECORD

Proj. No.	Project Title
GC002737-01	Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, C. Perry

DATE	TIME	SAMPLE I.D.	TPH-8015 Mod.	BTEX-624/8021 Mod.	Container No.	Number of Containers	Remarks
9.25.98	1520	GP-16	X	X	VOA	2	HCl
9.28.98	1100	GP-17	X	X	"	2	"
9.25.98	1150	GP-8	X	X	"	2	"
9.24.98	1545	GP-9C	X	X	"	2	"
9.24.98	1415	GP-6	X	X	"	2	"
9.25.98	1015	GP-9B	X	X	"	2	"
9.25.98	1340	GP-15	X	X	"	2	"
9.28.98	1445	GP-20	X	X	"	2	"
9.28.98	1245	GP-21	X	X	"	2	"
9.28.98	1215	GP-Rinsate	X	X	"	2	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
J. Kramer	9.28.98 16:00	Jill Hetzler 9/29/98			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

of

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Sacramento, California
(916) 366-9089
FAX: (916) 366-9138

ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: Rhein-Main AB
Phone: (614) 424-3779
Attn: Julie Kramer

Methodology: TPHE - Modified 8015/DHS LUFT Manual - Extractable

	Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID : **MW-1**	TPH-E (Jet Fuel)	ND	0.050 mg/L	01-Oct-98	06-Oct-98
Lab ID : 98100210-17A	TPH-E (Diesel)	ND	0.050 mg/L	01-Oct-98	06-Oct-98
	TPH-E (Oil)	ND	0.50 mg/L	01-Oct-98	06-Oct-98
Client ID : **MW2**	TPH-E (Jet Fuel)	ND	0.050 mg/L	30-Sep-98	09-Oct-98
Lab ID : 98100210-19A	TPH-E (Diesel)	ND	0.050 mg/L	30-Sep-98	09-Oct-98
	TPH-E (Oil)	ND	0.50 mg/L	30-Sep-98	09-Oct-98

ND = Not Detected

Approved By: Roger Scholl Date: 10/14/98

Roger L. Scholl, Ph.D.
Laboratory Director

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ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: Rhein-Main AB
Phone: (614) 424-6315
Attn: Julie Kramer

Methodology: TPHP - Modified 8015/DHS LUFT Manual - Purgeable
VOCs - Method 8260

		Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID :	**GP-23**	TPH Purgeable	ND	0.050 mg/L	9/30/98	10/7/98
Lab ID :	98100210-01A	Benzene	ND	0.50 µg/L	9/30/98	10/7/98
		Toluene	ND	0.50 µg/L	9/30/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/30/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/30/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/30/98	10/7/98
Client ID :	**GP-25**	TPH Purgeable	ND	0.050 mg/L	9/30/98	10/7/98
Lab ID :	98100210-02A	Benzene	ND	0.50 µg/L	9/30/98	10/7/98
		Toluene	ND	0.50 µg/L	9/30/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/30/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/30/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/30/98	10/7/98
Client ID :	**GP-19**	TPH Purgeable	ND	0.050 mg/L	9/29/98	10/7/98
Lab ID :	98100210-03A	Benzene	ND	0.50 µg/L	9/29/98	10/7/98
		Toluene	ND	0.50 µg/L	9/29/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/29/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/29/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/29/98	10/7/98
Client ID :	**GP-12**	TPH Purgeable	ND	0.050 mg/L	9/29/98	10/7/98
Lab ID :	98100210-04A	Benzene	ND	0.50 µg/L	9/29/98	10/7/98
		Toluene	ND	0.50 µg/L	9/29/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/29/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/29/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/29/98	10/7/98
Client ID :	**GP-11**	TPH Purgeable	0.14	0.050 mg/L	9/28/98	10/7/98
Lab ID :	98100210-05A	Benzene	0.61	0.50 µg/L	9/28/98	10/7/98
		Toluene	ND	0.50 µg/L	9/28/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/7/98

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Client ID :	**GP-18**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/7/98
Lab ID :	98100210-06A	Benzene	ND	0.50 µg/L	9/28/98	10/7/98
		Toluene	ND	0.50 µg/L	9/28/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
Client ID :	**GP-18-D**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/7/98
Lab ID :	98100210-07A	Benzene	ND	0.50 µg/L	9/28/98	10/7/98
		Toluene	ND	0.50 µg/L	9/28/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
Client ID :	**GP-Rinsate**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/7/98
Lab ID :	98100210-08A	Benzene	ND	0.50 µg/L	9/28/98	10/7/98
		Toluene	ND	0.50 µg/L	9/28/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
Client ID :	**GP-18-FB**	TPH Purgeable	ND	0.050 mg/L	9/28/98	10/7/98
Lab ID :	98100210-09A	Benzene	ND	0.50 µg/L	9/28/98	10/7/98
		Toluene	ND	0.50 µg/L	9/28/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/28/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/28/98	10/7/98
Client ID :	**GP-1-10M**	TPH Purgeable	1.5	0.050 mg/L	9/30/98	10/7/98
Lab ID :	98100210-10A	Benzene	9.3	0.50 µg/L	9/30/98	10/7/98
		Toluene	ND	0.50 µg/L	9/30/98	10/7/98
		Ethylbenzene	5.8	0.50 µg/L	9/30/98	10/7/98
		m,p-Xylene	13	0.50 µg/L	9/30/98	10/7/98
		o-Xylene	1.7	0.50 µg/L	9/30/98	10/7/98
Client ID :	**GP-7**	TPH Purgeable	0.14	0.050 mg/L	9/30/98	10/7/98
Lab ID :	98100210-11A	Benzene	ND	0.50 µg/L	9/30/98	10/7/98
		Toluene	ND	0.50 µg/L	9/30/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	9/30/98	10/7/98
		m,p-Xylene	ND	0.50 µg/L	9/30/98	10/7/98
		o-Xylene	ND	0.50 µg/L	9/30/98	10/7/98

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21
Sparks, Nevada 89431-5778
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Sacramento, California
(916) 366-9089
FAX: (916) 366-9138

Client ID :	**GP3-10M**	TPH Purgeable	6.6		0.25 mg/L	10/1/98	10/8/98
Lab ID :	98100210-12A	Benzene	330		1.0 µg/L	10/1/98	10/8/98
		Toluene	ND	B	1.0 µg/L	10/1/98	10/8/98
		Ethylbenzene	340		1.0 µg/L	10/1/98	10/8/98
		m,p-Xylene	880		1.0 µg/L	10/1/98	10/8/98
		o-Xylene	5.8		1.0 µg/L	10/1/98	10/8/98
Client ID :	**GP1-14M**	TPH Purgeable	12		2.5 mg/L	10/1/98	10/6/98
Lab ID :	98100210-13A	Benzene	1400		10 µg/L	10/1/98	10/6/98
		Toluene	78		10 µg/L	10/1/98	10/6/98
		Ethylbenzene	870		10 µg/L	10/1/98	10/6/98
		m,p-Xylene	1500		10 µg/L	10/1/98	10/6/98
		o-Xylene	520		10 µg/L	10/1/98	10/6/98
Client ID :	**GP1-17M**	TPH Purgeable	0.076		0.050 mg/L	10/1/98	10/8/98
Lab ID :	98100210-14A	Benzene	ND		0.50 µg/L	10/1/98	10/8/98
		Toluene	ND		0.50 µg/L	10/1/98	10/8/98
		Ethylbenzene	ND		0.50 µg/L	10/1/98	10/8/98
		m,p-Xylene	ND		0.50 µg/L	10/1/98	10/8/98
		o-Xylene	ND		0.50 µg/L	10/1/98	10/8/98
Client ID :	**MW-1**	TPH Purgeable	12	*	0.050 mg/L	10/1/98	10/7/98
Lab ID :	98100210-15A	Benzene	800	*	0.50 µg/L	10/1/98	10/7/98
		Toluene	980	*	0.50 µg/L	10/1/98	10/7/98
		Ethylbenzene	390	*	0.50 µg/L	10/1/98	10/7/98
		m,p-Xylene	1100	*	0.50 µg/L	10/1/98	10/7/98
		o-Xylene	690	*	0.50 µg/L	10/1/98	10/7/98
Client ID :	**GP3-14M**	TPH Purgeable	0.068		0.050 mg/L	9/30/98	10/8/98
Lab ID :	98100210-16A	Benzene	0.56		0.50 µg/L	9/30/98	10/8/98
		Toluene	ND		0.50 µg/L	9/30/98	10/8/98
		Ethylbenzene	ND		0.50 µg/L	9/30/98	10/8/98
		m,p-Xylene	ND		0.50 µg/L	9/30/98	10/8/98
		o-Xylene	ND		0.50 µg/L	9/30/98	10/8/98
Client ID :	**MW2**	TPH Purgeable	57		2.5 mg/L	9/30/98	10/6/98
Lab ID :	98100210-17A	Benzene	20000		10 µg/L	9/30/98	10/6/98
		Toluene	14000		10 µg/L	9/30/98	10/6/98
		Ethylbenzene	750		10 µg/L	9/30/98	10/6/98
		m,p-Xylene	2000		10 µg/L	9/30/98	10/6/98
		o-Xylene	800		10 µg/L	9/30/98	10/6/98

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FAX: (916) 366-9133

*-The measured concentration is somewhat less than the true value because of detector saturation. Only one vial was available for a single analysis.

ND = Not Detected

B = Detection Limits were raised due to high concentrations of target analytes.

Approved By: Roger Scholl
Roger L. Scholl, Ph.D.
Laboratory Director

Date: 10/19/98

CR

Billing Information :
Battelle
505 King Avenue

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98100210

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job : Rhein-Main AB
PO :
QC Level :

Sampled by : J. Kramer, C. Perry
Cooler Temp : °C

Report Attention : Julie Kramer

02-Oct-98

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_W	TPH/E_W	TPH/P_W						Sample Remarks
BMI98100210-01	GP-23	AQ	9/30/98	2	10		A		A						BTEX BY 8240 MOD.
BMI98100210-02	GP-25	AQ	9/30/98	2	10		A		A						BTEX BY 8240 MOD.
BMI98100210-03	GP-19	AQ	9/29/98	2	10		A		A						BTEX BY 8240 MOD.
BMI98100210-04	GP-12	AQ	9/29/98	2	10		A		A						BTEX BY 8240 MOD.
BMI98100210-05	GP-11	AQ	9/28/98	2	10		A		A						BTEX BY 8240 MOD.
BMI98100210-06	GP-18	AQ	9/28/98	2	10		A		A						BTEX BY 8240 MOD.
BMI98100210-07	GP-18-D	AQ	9/28/98	1	10		A		A						BTEX BY 8240 MOD.
BMI98100210-08	GP-Rinsate	AQ	9/28/98	1	10		A		A						BTEX BY 8240 MOD.
BMI98100210-09	GP-18-FB	AQ	9/28/98	1	10		A		A						BTEX BY 8240 MOD.
BMI98100210-10	GP-1-10M	AQ	9/30/98	2	10		A		A						BTEX BY 8240 MOD.

Comments: SAMPLES FROM GERMANY. tph/p only per RG 9/30 TPH/E added to 19 per Julie Kramer 10/6 HE

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Heidi Eskew	H. Eskew	Alpha	10/2/98 210pm
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

 Ca

CHAIN-OF-CUSTODY RECORD

Billing Information :
Battelle
505 King Avenue

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98100210

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job : Rhein-Main AB
PO :
QC Level :

Sampled by : J. Kramer, C. Perry

Cooler Temp : °C

02-Oct-98

Report Attention : Julie Kramer

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_W	TPH/E_W	TPH/P_W							Sample Remarks
BMI98100210-11	GP-7	AQ	9/30/98	~~2~~ 5	10		A		A							BTEX BY 8240 MOD.
BMI98100210-~~12~~	GP-7-Matrix Spike	AQ	9/30/98	1	10		A		A							BTEX BY 8240 MOD.
BMI98100210-~~13~~	GP-7-Matrix Spike Dup.	AQ	9/30/98	2	10		A		A							BTEX BY 8240 MOD.
BMI98100210-~~14~~ 12	GP3-10M	AQ	10/1/98	2	10		A		A							BTEX BY 8240 MOD.
BMI98100210-~~15~~ 13	GP1-14M	AQ	10/1/98	2	10		A		A							BTEX BY 8240 MOD.
BMI98100210-~~16~~ 14	GP1-17M	AQ	10/1/98	2	10		A		A							BTEX BY 8240 MOD.
BMI98100210-~~17~~ 15	MW-1	AQ	10/1/98	2	10		A	A	A							BTEX BY 8240 MOD. THIS SAMPLE WILL HAVE A VERY HIGH CONCENTRATION
BMI98100210-~~18~~ 16	GP3-14M	AQ	9/30/98	2	10		A		A							BTEX BY 8240 MOD.

Tammy! no charges per RG 10/15 JR

Comments: SAMPLES FROM GERMANY. tph/p only per RG 9/30

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Heidi Eskew	H. Eskew	Alpha	10/2/98 210 pm
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangen... are made. Hazardous samples will be returned to client or disposed of at client expense.
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Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Ca

CHAIN-OF-CUSTODY RECORD

Billing Information :
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TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98100210

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job : Rhein-Main AB
PO :
QC Level :

Sampled by : J. Kramer, C. Perry

Cooler Temp : °C

02-Oct-98

Report Attention : Julie Kramer

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	BTEX_W	TPH/E_W	TPH/P_W						Sample Remarks
BMI98100210-~~19~~ 17	MW2	AQ	9/30/98	2	10		A	A	A						BTEX BY 8240 MOD.

(Requested Tests: BTEX_W, TPH/E_W, TPH/P_W)

added per Julie Kramer 10/14 HE

Comments: SAMPLES FROM GERMANY. tph/p only per RG 9/30

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Heidi Eskew	H. Eskew	Alpha	10/2/98 2:10pm
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other)   Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ____________

Proj. No. G002737-01

Project Title Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, C. Perry

DATE	TIME	SAMPLE I.D.	BTEX-624/8240 Mod.	TPH-8015 Mod.	Container No.	Number of Containers	Remarks
9.30.98	1110	GP-23	X	X		2 VOA	HCl ✓
9.30.98	1320	GP-25	X	X		"	HCl ✓
9.29.98	1550	GP-19	X	X		"	HCl ✓
9.29.98	1118	GP-12	X	X		"	HCl ✓
9.29.98	1350	GP-11	X	X		"	HCl ✓
9.28.98	1635	GP-18	X	X		"	HCl ✓
9.28.98	1635	GP-18-D	X	X		1 VOA	HCl ✓
9.28.98	1215	GP-Rinsate	X	X		1 VOA	HCl ✓
9.28.98	1632	GP-18-FB	X	X		1 VOA	HCl ✓
9.30.98	1745	GP-1-10M	X	X		2 VOA	" ✓
9.30.98	1545	GP-7	X	X		2 VOA	" ✓
9.30.98	1545	GP-7-Matrix Spike	X	X		1 VOA	" ✓
9.30.98	1545	GP-7-Matrix Spike Dup.	X	X		2 VOA	" ✓
10.1.98	1230	GP3-10M	X	X		2 VOA	" ✓
10.1.98	920	GP1-14M	X	X		2 VOA	" ✓
10.1.98	1050	GP1-17M	X	X		2 VOA	" ✓
10.1.98	1255	MW-1	X	X	Purgeable & Extractable	2 VOA	" High Conc ✓

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	10.1.98 16:00	Heidi Eskew			
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**
Relinquished by: (Signature)	**Date/Time**	**Received for Laboratory by: (Signature)**	**Date/Time**	**Remarks**	
				MW-1 will have very high concentration	

Battelle
Columbus Laboratories

Form No. ______

CHAIN OF CUSTODY RECORD

Proj. No.	Project Title
GD02737-01	Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, C Perry

DATE	TIME	SAMPLE I.D.	BTEX-624/8240 Mod.	TPH-8015 Mod.	Container No.	Number of Containers	Remarks
9.30.98	14 20	GP3-14M	X	X		2VOA	HCl
9.30.98	15 30	MW2	X	X		2VOA	HCl

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	10.1.98 16:00	Heidi Askew			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

(W)

CHAIN-OF-CUSTODY RECORD

Billing Information :
Battelle
505 King Avenue

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98100501

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job : Rhein-Main AB
PO :
QC Level :

Sampled by : J. Kramer, C. Perry

Cooler Temp : °C

05-Oct-98

Report Attention : Julie Kramer

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_W	TPH/E_W	TPH/P_W	Sample Remarks
BMI98100501-01	MW3	AQ	10/2/98	2	10		A	A	A	VERY HIGH CONCENTRATION
BMI98100501-02	GP5-14M	AQ	10/1/98	2	10		A		A	
BMI98100501-03	GP3-17M	AQ	10/1/98	2	10		A		A	

Comments: Ca detection limits. Foreign Samples.

	Signature	Print Name	Company	Date/Time
Relinquished by:	Heidi Esken	H. Eskcw	alpha	10/5/98 1050
Received by:				
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No. G002737

Project Title: Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, C. Perry

DATE	TIME	SAMPLE I.D.	BTEX-624/8240 Mod.	TPH-8015 Mod.	SAMPLE TYPE (√)	Container No.	Number of Containers	Remarks
10.2.98	10 30	MW3	X	X	Purgeable & Extract for MW3		2 VOA	HCl - very high conc
10.1.98	18 30	GP5-14M	X	X			2 VOA	HCl
10.1.98	16 45	GP3-17M	X	X			2 VOA	HCl - ~~[illegible]~~

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	10.2.98 16:00				
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	
		Heidi Askew	10/5/98 1050		

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(916) 366-9089
FAX: (916) 366-9138

ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: Rhein-Main AB
Phone: (614) 424-3779
Attn: Julie Kramer

Methodology: TPHP - Modified 8015/DHS LUFT Manual - Purgeable
VOCs - Method 8260

		Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID :	**MW3**	TPH Purgeable	18	2.5 mg/L	10/2/98	10/8/98
Lab ID :	98100501-01A	Benzene	4600	20 µg/L	10/2/98	10/8/98
		Toluene	3300	20 µg/L	10/2/98	10/8/98
		Ethylbenzene	510	20 µg/L	10/2/98	10/8/98
		m,p-Xylene	1500	20 µg/L	10/2/98	10/8/98
		o-Xylene	420	20 µg/L	10/2/98	10/8/98
Client ID :	**GP5-14M**	TPH Purgeable	7.0	0.25 mg/L	10/1/98	10/8/98
Lab ID :	98100501-02A	Benzene	99	2.0 µg/L	10/1/98	10/8/98
		Toluene	5.2	2.0 µg/L	10/1/98	10/8/98
		Ethylbenzene	270	2.0 µg/L	10/1/98	10/8/98
		m,p-Xylene	1700	2.0 µg/L	10/1/98	10/8/98
		o-Xylene	61	2.0 µg/L	10/1/98	10/8/98
Client ID :	**GP3-17M**	TPH Purgeable	0.085	0.050 mg/L	10/1/98	10/7/98
Lab ID :	98100501-03A	Benzene	ND	0.50 µg/L	10/1/98	10/7/98
		Toluene	ND	0.50 µg/L	10/1/98	10/7/98
		Ethylbenzene	ND	0.50 µg/L	10/1/98	10/7/98
		m,p-Xylene	0.5	0.50 µg/L	10/1/98	10/7/98
		o-Xylene	ND	0.50 µg/L	10/1/98	10/7/98

ND = Not Detected

Approved By: Roger Scholl
Roger L. Scholl, Ph.D.
Laboratory Director

Date: 10/9/98

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Sparks, Nevada 89431-5778
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Sacramento, California
(916) 366-9089
FAX: (916) 366-9138

ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: Rhein-Main AB
Phone: (614) 424-6315
Attn: Julie Kramer

Methodology: TPHE - Modified 8015/DHS LUFT Manual - Extractable

	Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID : **MW3**	TPH-E (Jet Fuel)	ND	0.050 mg/L	02-Oct-98	08-Oct-98
Lab ID : 98100501-01A	TPH-E (Diesel)	150	0.050 mg/L	02-Oct-98	08-Oct-98
	TPH-E (Oil)	ND	0.50 mg/L	02-Oct-98	08-Oct-98

ND = Not Detected

Approved By: Roger Scholl
Roger L. Scholl, Ph.D.
Laboratory Director

Date: 10/15/98

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ANALYTICAL REPORT

Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Job#: Rhein-Main AB
Phone: (614) 424-3779
Attn: Julie Kramer

Methodology: TPHP - Modified 8015/DHS LUFT Manual - Purgeable
VOCs - Method 8260

	Parameter	Concentration	Reporting Limit	Date Sampled	Date Analyzed
Client ID : **MWI-.60-.75**	TPH Purgeable	2.6	1.0 mg/Kg	9/21/98	10/1/98
Lab ID : 98092642-01A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
	o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID : **MWI-.75-.89**	TPH Purgeable	6.0	1.0 mg/Kg	9/21/98	10/1/98
Lab ID : 98092642-02A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
	o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID : **MWI-1.06-1.22**	TPH Purgeable	6.0	1.0 mg/Kg	9/21/98	10/1/98
Lab ID : 98092642-03A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
	o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID : **MWI-1.64-1.78**	TPH Purgeable	34	1.0 mg/Kg	9/21/98	10/1/98
Lab ID : 98092642-04A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
	o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID : **MWI-6.0-6.15**	TPH Purgeable	3.2	1.0 mg/Kg	9/21/98	10/1/98
Lab ID : 98092642-05A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
	Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
	m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
	o-Xylene	6.4	5.0 µg/Kg	9/21/98	10/1/98

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Client ID :	**MWI-6.7-6.85**	TPH Purgeable	1.5	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-06A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**MWI-6.85-7.0**	TPH Purgeable	ND	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-07A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**MWI-7.47-7.62**	TPH Purgeable	ND	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-08A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW2-.46-.61**	TPH Purgeable	77	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-09A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW2-1.07-1.22**	TPH Purgeable	14	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-10A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW2-2.29-2.44**	TPH Purgeable	1.4	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-11A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98

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Client ID :	**VW2-5.03-5.18**	TPH Purgeable	7.5	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-12A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW2-5.34-5.48**	TPH Purgeable	ND	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-13A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW2-8.48-8.63**	TPH Purgeable	2.6	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-14A	Benzene	610	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	130	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	16	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	42	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	10	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW1-4.66-4.82**	TPH Purgeable	ND	1.0 mg/Kg	9/21/98	10/1/98
Lab ID :	98092642-15A	Benzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/1/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/1/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/1/98
Client ID :	**VW1-7.56-7.71**	TPH Purgeable	66	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-16A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	6.7	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
Client ID :	**VW1-7.84-8.0**	TPH Purgeable	43	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-17A	Benzene	29	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	18	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	19	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98

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Client ID :	**VW4-7.2-7.35**	TPH Purgeable	1.1	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-18A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
Client ID :	**VW4-7.35-7.5**	TPH Purgeable	ND	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-19A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
Client ID :	**VW4-7.5-7.65**	TPH Purgeable	11	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-20A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
Client ID :	**VW4-7.65-7.8**	TPH Purgeable	29	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-21A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
Client ID :	**VW4-8.0-8.15**	TPH Purgeable	1.4	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-22A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
Client ID :	**VW4-8.30-8.50**	TPH Purgeable	15	1.0 mg/Kg	9/21/98	10/2/98
Lab ID :	98092642-23A	Benzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/21/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/21/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/21/98	10/2/98

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Client ID :	**VW4-8.65-8.8**	TPH Purgeable	4300	250 mg/Kg	9/21/98	9/29/98
Lab ID :	98092642-24A	Benzene	4300	1000 µg/Kg	9/21/98	9/29/98
		Toluene	27000	1000 µg/Kg	9/21/98	9/29/98
		Ethylbenzene	4200	1000 µg/Kg	9/21/98	9/29/98
		m,p-Xylene	10000	1000 µg/Kg	9/21/98	9/29/98
		o-Xylene	2800	1000 µg/Kg	9/21/98	9/29/98
Client ID :	**VWI-8.11-8.26**	TPH Purgeable	160	1.0 mg/Kg	9/22/98	10/2/98
Lab ID :	98092642-25A	Benzene	180	5.0 µg/Kg	9/22/98	10/2/98
		Toluene	14	5.0 µg/Kg	9/22/98	10/2/98
		Ethylbenzene	200	5.0 µg/Kg	9/22/98	10/2/98
		m,p-Xylene	510	5.0 µg/Kg	9/22/98	10/2/98
		o-Xylene	29	5.0 µg/Kg	9/22/98	10/2/98
Client ID :	**VW1-8.26-8.41**	TPH Purgeable	2000	250 mg/Kg	9/22/98	9/29/98
Lab ID :	98092642-26A	Benzene	4400	1000 µg/Kg	9/22/98	9/29/98
		Toluene	2500	1000 µg/Kg	9/22/98	9/29/98
		Ethylbenzene	5500	1000 µg/Kg	9/22/98	9/29/98
		m,p-Xylene	16000	1000 µg/Kg	9/22/98	9/29/98
		o-Xylene	ND	1000 µg/Kg	9/22/98	9/29/98
Client ID :	**VW1-8.81-9.0**	TPH Purgeable	5600	250 mg/Kg	9/22/98	9/29/98
Lab ID :	98092642-27A	Benzene	27000	1000 µg/Kg	9/22/98	9/29/98
		Toluene	3800	1000 µg/Kg	9/22/98	9/29/98
		Ethylbenzene	22000	1000 µg/Kg	9/22/98	9/29/98
		m,p-Xylene	83000	1000 µg/Kg	9/22/98	9/29/98
		o-Xylene	20000	1000 µg/Kg	9/22/98	9/29/98
Client ID :	**VW3-8.0-8.33**	TPH Purgeable	55	2.0 mg/Kg	9/22/98	10/2/98
Lab ID :	98092642-28A	Benzene	ND	8.0 µg/Kg	9/22/98	10/2/98
		Toluene	ND	8.0 µg/Kg	9/22/98	10/2/98
		Ethylbenzene	21	8.0 µg/Kg	9/22/98	10/2/98
		m,p-Xylene	45	8.0 µg/Kg	9/22/98	10/2/98
		o-Xylene	8.5	8.0 µg/Kg	9/22/98	10/2/98
Client ID :	**VW3-8.33-8.67**	TPH Purgeable	750	50 mg/Kg	9/22/98	10/2/98
Lab ID :	98092642-29A	Benzene	ND	200 µg/Kg	9/22/98	10/2/98
		Toluene	210	200 µg/Kg	9/22/98	10/2/98
		Ethylbenzene	580	200 µg/Kg	9/22/98	10/2/98
		m,p-Xylene	1500	200 µg/Kg	9/22/98	10/2/98
		o-Xylene	ND	200 µg/Kg	9/22/98	10/2/98

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Client ID :	**VW3-8.68-9.0**	TPH Purgeable	150	5.0 mg/Kg	9/22/98	10/2/98
Lab ID :	98092642-30A	Benzene	ND	20 µg/Kg	9/22/98	10/2/98
		Toluene	31	20 µg/Kg	9/22/98	10/2/98
		Ethylbenzene	350	20 µg/Kg	9/22/98	10/2/98
		m,p-Xylene	880	20 µg/Kg	9/22/98	10/2/98
		o-Xylene	53	20 µg/Kg	9/22/98	10/2/98
Client ID :	**VW3-7.16-7.32**	TPH Purgeable	2.3	1.0 mg/Kg	9/22/98	10/2/98
Lab ID :	98092642-31A	Benzene	ND	5.0 µg/Kg	9/22/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/22/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/22/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/22/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/22/98	10/2/98
Client ID :	**VW3-7.32-7.48**	TPH Purgeable	ND	1.0 mg/Kg	9/22/98	10/2/98
Lab ID :	98092642-32A	Benzene	ND	5.0 µg/Kg	9/22/98	10/2/98
		Toluene	ND	5.0 µg/Kg	9/22/98	10/2/98
		Ethylbenzene	ND	5.0 µg/Kg	9/22/98	10/2/98
		m,p-Xylene	ND	5.0 µg/Kg	9/22/98	10/2/98
		o-Xylene	ND	5.0 µg/Kg	9/22/98	10/2/98

ND = Not Detected

Approved By: Roger Scholl

Roger L. Scholl, Ph.D.
Laboratory Director

Date: 10/5/98

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No. G002737-01

Project Title Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, C. Perry

	DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
01 ✓	9/21/98	11:50	MW1 - .60 - .75 ✓	X	X		1	Soil sample
02 ✓	"	11:50	MW1 - .75 - .89 ✓	X	X		1	"
03 ✓	"	12:00	MW1 - 1.06 - 1.22 ✓	X	X		1	"
04 ✓	"	12:00	MW1 - 1.64 - 1.78	X	X		1	"
05 ✓	"	12:35	MW1 - 6.0 - 6.15	X	X		1	"
06 ✓	"	12:55	MW1 - 6.7 - 6.85	X	X		1	"
07 ✓	"	12:55	MW1 - 6.85 - 7.0	X	X		1	"
08 ✓	"	13:05	MW1 - 7.47 - 7.62	X	X		1	"
09 ✓	"	13:20	VW2 - .46 - .61	X	X		1	"
10 ✓	" SM	13:~~30~~ 40	VW2 - 1.07 - 1.22	X	X		1	"
11 ✓	"	13:40	VW2 - 2.29 - 2.44	X	X		1	"
12 ✓	"	14:15	VW2 - 5.03 - 5.18	X	X		1	"
13 ✓	"	14:15	VW2 - 5.34 - 5.49	X	X		1	"
14 ✓	"	14:50	VW2 - 8.48 - 8.63	X	X		1	"
15 ✓	"	15:05	VW1 - 4.66 - 4.82	X	X		1	"
16 ✓	"	16:00	VW1 - 7.56 - 7.71	X	X		1	"
17	"	16:00	VW1 - 7.84 - 8.0	X	X		1	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	9.23.98 17:00				
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**
Relinquished by: (Signature)	**Date/Time**	**Received for Laboratory by: (Signature)**	**Date/Time**	**Remarks**	

BMI 98092642

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No.	Project Title
G002737-01	Rhein-Main AB

SAMPLERS: (Signature) J. Kramer, C. Perry

	DATE	TIME	SAMPLE I.D.	TPH-8015	BTEX-8240	Container No.	Number of Containers	Remarks
18 ✓	9/21/98	17:25	VW4-7.2-7.35	X	X		1	Soil sample
19 ✓	"	17:25	VW4-7.35-7.5	X	X		1	"
20 ✓	"	17:25	VW4-7.5-7.65	X	X		1	"
21 ✓	"	17:25	VW4-7.65-7.8	X	X		1	"
22 ✓	"	17:35	VW4-8.0-8.15	X	X		1	"
23 ✓	"	17:35	VW4-8.30-8.50	X	X		1	"
24 ✓	"	17:35	VW4-8.65-8.8	X	X		1	"
25 ✓	9/22/98	9:25	[redacted] VW1-8.11-8.26	X	X		1	"
26 ✓	9/22/98	9:25	VW1-8.26-8.41	X	X		1	"
27 ✓	9/22/98	9:25	VW1-8.81-9.0	X	X		1	"
28 ✓	"	10:35	VW3-8.0-8.33	X	X		1	"
29 ✓	"	10:35	VW3-8.33-8.67	X	X		1	"
30 ✓	"	10:35	VW3-8.67-9.0	X	X		1	"
31 ✓	"	10:25	VW3-7.16-7.32	X	X		1	"
32 ✓	"	10:25	VW3-7.32-7.48	X	X		1	"
							1	"
							1	"

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Julie Kramer	9.23.98 17:00	[signature] 9:00 9/26/98			
Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks	

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98092642

Billing Information :
Battelle
505 King Avenue

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Report Attention : ~~Chris Zimmerman~~ Julie Kramer

TEL : (614) 424-3779
FAX : (614) 424-3667
Job :
PO :
QC Level :

Sampled by :
Cooler Temp : °C

26-Sep-98

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_S	TPH/P_S							Sample Remarks
BMI98092642-01	MWI-.60-.75	SO	9/21/1998	1	10		^	^							
BMI98092642-02	MWI-.75-.89	SO	9/21/1998	1	10		^	^							
BMI98092642-03	MWI-1.06-1.22	SO	9/21/1998	1	10		^	^							
BMI98092642-04	MWI-1.64-1.78	SO	9/21/1998	1	10		^	^							
BMI98092642-05	MWI-6.0-6.15	SO	9/21/1998	1	10		^	^							
BMI98092642-06	MWI-6.7-6.85	SO	9/21/1998	1	10		^	^							
BMI98092642-07	MWI-6.85-7.0	SO	9/21/1998	1	10		^	^							
BMI98092642-08	MWI-7.47-7.62	SO	9/21/1998	1	10		^	^							
BMI98092642-09	VW2-.46-.61	SO	9/21/1998	1	10		^	^							
BMI98092642-10	VW2-1.07-1.22	SO	9/21/1998	1	10		^	^							

FOR SOILS FOREIGN

Comments: PROJECT-TITLE RHEIN-MAIN AB FOR SOIL FOREIGN

	Signature	Print Name		
Relinquished by:				
Received by:	[signature]	S. Miller	AAL	9/26/98
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Billing Information :
Battelle
505 King Avenue

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98092642

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job :
PO :
QC Level :

Sampled by :

Cooler Temp : °C

26-Sep-98

Report Attention : ~~Chris Zimmerman~~ Julie Kramer

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_S	TPH/P_S							Sample Remarks
BMI98092642-11	VW2-2.29-2.44	SO	9/21/1998	1	10		^	^							
BMI98092642-12	VW2-5.03-5.18	SO	9/21/1998	1	10		^	^							
BMI98092642-13	VW2-5.34-5.48	SO	9/21/1998	1	10		^	^							
BMI98092642-14	VW2-8.48-8.63	SO	9/21/1998	1	10		^	^							
BMI98092642-15	VW1-4.66-4.82	SO	9/21/1998	1	10		^	^							
BMI98092642-16	VW1-7.56-7.71	SO	9/21/1998	1	10		^	^							
BMI98092642-17	VW1-7.84-8.0	SO	9/21/1998	1	10		^	^							
BMI98092642-18	VW4-7.2-7.35	SO	9/21/1998	1	10		^	^							
BMI98092642-19	VW4-7.35-7.5	SO	9/21/1998	1	10		^	^							
BMI98092642-20	VW4-7.5-7.65	SO	9/21/1998	1	10		^	^							

Comments: PROJECT-TITLE RHEIN-MAIN AB

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Shinane Mill[illegible]			
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense. The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.

Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other)   Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Billing Information :
Battelle
505 King Avenue

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98092642

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

TEL : (614) 424-3779
FAX : (614) 424-3667
Job :
PO :
QC Level :

Sampled by :

Cooler Temp : °C

26-Sep-98

Report Attention : ~~Chris Zimmerman~~ Julie Kramer

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	Requested Tests: BTEX_S	TPH/P_S								Sample Remarks
BMI98092642-21	VW4-7.65-7.8	SO	9/21/1998	1	10		A	A								
BMI98092642-22	VW4-8.0-8.15	SO	9/21/1998	1	10		A	A								
BMI98092642-23	VW4-8.30-8.50	SO	9/21/1998	1	10		A	A								
BMI98092642-24 •	VW4-8.65-8.8	SO	9/21/1998	1	10		A	A								
BMI98092642-25	VWI-8.11-8.26	SO	9/22/1998	1	10		A	A								
BMI98092642-26 •	VW1-8.226-8.41	SO	9/22/1998	1	10		A	A								
BMI98092642-27 •	VW1-8.81-9.0	SO	9/22/1998	1	10		A	A								
BMI98092642-28	VW3-8.0-8.33	SO	9/22/1998	1	10		A	A								
BMI98092642-29	VW3-8.33-8.67	SO	9/22/1998	1	10		A	A								
BMI98092642-30	VW3-8.68-9.0	SO	9/22/1998	1	10		A	A								

Comments: PROJECT-TITLE RHEIN-MAIN AB

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	[illegible]			
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.
Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other)   Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431
TEL: (702) 355-1044 FAX: (702) 355-0406

WorkOrder:
BMI98092642

Billing Information :
Battelle
505 King Avenue

Client:
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

Report Attention : ~~Chris Zimmerman~~ Julie Kramer

TEL : (614) 424-3779
FAX : (614) 424-3667
Job :
PO :
QC Level :

Sampled by :
Cooler Temp : °C

26-Sep-98

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles	TAT	PWS #	BTEX_S	TPH/P_S							Sample Remarks
BMI98092642-31	VW3-7.16-7.32	SO	9/22/1998	1	10		A	A							
BMI98092642-32	VW3-7.32-7.48	SO	9/22/1998	1	10		A	A							

Comments: PROJECT-TITLE RHEIN-MAIN AB

	Signature	Print Name	Company	Date/Time
Relinquished by:				
Received by:	Yvonne Kulbe			
Relinquished by:				
Received by:				

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense. The report for the analysis of the above samples is applicable only to those samples received by the laboratory with this COC. The liability of the laboratory is limited to the amount paid for the report.

Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

APPENDIX B

SOIL BORING LOGS

Battelle

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BORING LOG

Project #: 6002737-01	Site: Rhein Main AB POL Yard	Boring #: VW-1 (Pg 1/2)
Drilling Method: Auger	Rig Type: Rotary	Date: 4/3/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Terry

Depth (feet bgs)	Sample ID	USCS	Sample description
1		ML	silt & clay; dark brown; organic; some gravel
3		SP	silty sand; dark brown (as above) less organic; slightly moist; trace gravel (1/2–3/4" diameter)
4		SP	sand; med grained qtzic; slight iron mottling, subround, moist, trace small gravel (< 1/8") near 4.5'
5–6		SW	poor sorted sand, med brown, moist, med. grain; some silt (10%) 1 or 2 gravels (< 1/8" diam) NO ODOR
7		SW	sand, coarse grained; poor sorted, 5–10% gravel (1/4–1" diam) mottled, some dark brown woody organic zones, moist NO ODOR
8		SP	sand, dk brn, med grnd, well sorted; zone (~4") of cs–vcsd w/gravel 1/8–1" diam; moist, quartz NO ODOR
9		SP	sand, well sorted, gravel (1/2–1" diam) qtzc, subrounded
10		SG	sand, med brown, quartzic; gravel from 1/8–3/4" diam; moist
11		SW	sand, poorly sorted; fine to medium-grained; gravel (< 1/8–3/4")
12		SP	sand, well sorted, medium to light brown; gravely (1/2–1 1/4") trace silt NO ODOR
13		SW	sand, moderate sorting, subrounded, med brown, fine grained NO ODOR
14		SW	sand, silty & gravely, med brown, moist, poor sorting NO ODOR
14.5		SG	sandy gravel; sand coarse grained; good – mod sorting
15		SW	sand, moderate sorting; gravely (1 1/4"); subang. FUEL ODOR
16		SP	sand, well sorted, med grained, qtzc dk grey FUEL ODOR
17		SW	sand, med–fine grained; poorly sorted, gravely GOOD FUEL ODOR
18		SP	sand, medium brown, med. grained, well sorted STRONG FUEL ODOR
19		SP	sand, medium brown–grey, med grained well sorted STRONG FUEL ODOR
20			GROUND WATER at 20.1 Feet

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BORING LOG

Project #: G002737-01	Site: Rhein Main AB POL Yard	Boring #: VW-1 (Pg 2/2)
Drilling Method: Auger	Rig Type: Rotary	Date: 4/4/96
Drilling Contractor: Kolis	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	USCS	Sample description
20			
21		SP	sand, well sorted, no odor, wet, looks like cavings
22		SP	sand, dark grey qtz, subrounded, well sorted FAIR FUEL ODOR - added water to pump gravel -
23		SP	sand, well sorted medium grained, coarsening downward
24			
25		SP	, sand, medium-grained, quartzic, subrounded SLIGHT FUEL ODOR
26			
27		SW	sand, coarse grained, trace gravel FAIR FUEL ODOR
28			Cannot drive split spoon deeper - clay at bottom of last spoon
29			TD well at 10.1 m or 32.8 ft.
30			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

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BORING LOG

Project #: 60027 37-01	Site: Rhein Main AB POL Yard.	Boring #: VW-2
Drilling Method: Auger	Rig Type: Rotary	Date: 4/9/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	USCS	Sample description
0–1		ML	silt, clayey, dark brown, moist, slight odor
2		SM	Sand, fine grained, silty (~10%); some gravel <1/8-3/4" diameter GOOD FUEL ODOR
3–4		SP	Sand; med-lite brown, subangular, qtzic, md grnd, poorly graded; some dark (Fe?) mottling FAIR-GOOD FUEL ODOR
5		SP	Sand; med brn; poorly graded FAIR FUEL ODOR
6		SW	Sand, med-cs grained; well graded; gravely FAIR ODOR
7		SW	Sand, med-cs grained; m-lt brn. qtzc. GOOD FUEL ODOR
9		SW	Sand; med-dk brn. med grnd; well graded; FAIR ODOR
10		SP	Sand - fine to med grained; med gray, NO FUEL ODOR
11		SP	Sand; med grnd; med brwn color SLi FUEL ODOR
12		SW	Sand; gravely (1/4-1/2" diam) med-dk brwn FUEL ODOR
13		SW	Sand; coarse grnd TRACE FUEL ODOR
14		SP	Sand; some clay; med grnd; med brn/gry
15		SP	Sand; med-fn grnd; sli gravely; GOOD FUEL ODOR
16		SP	Sand; gravely; cs grnd; almost sandy gravel
17		SW	Sand; fine grained w/some silt & trace gravel GOOD ODOR
18		SP	Sand; rubble zone; silty /well sorted below
19		SP	Sand; poorly graded, med grained
20		SP	Sand; poorly graded; qtzic; GOOD FUEL ODOR

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BORING LOG

Project #: 60027 37-01	Site: Rhein Main AB POL Yard.	Boring #: VW-2
Drilling Method: Auger	Rig Type: Rotary	Date: 4/9/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	Blow Counts	USCS	Sample description	OVA (ppm)	TPH (ppm)
20			SP	sand; poorly graded. GOOD FUEL ODOR		
21						
22				FUEL ODOR		
23			SP	Sand; med-cs grained; med. gray, qtzic; some gravel SLIGHT FUEL ODOR		
24			SP	Sand; as above		
25			SP	Sand; med-cs grained; as above FUEL ODOR		
26			SP	as above; no gravel SLIGHT FUEL ODOR		
27			SW	sand med grained; better graded; lt-med brwn. FAIR FUEL ODOR		
28			SW	sand fn. grnd w/some silt & clay		
29			SW	sand as above but better graded & w/more clay		
30			SM/SW	sand; med grained w/ silt (20%) & clay (25%) med-lt. brown; very clayey 30.5-30.7 ft		
31			SC/SW	sand; fine grained; very clayey (35-40%) w/ silt (25%).		
32						
33				Total Depth (drilled) @ 32.1 ft (9.8m)		
34						
35						
36						
17						
18						
19						
20						

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BORING LOG

Project #: G002737-01	Site: Rhein Main AB POL Yard	Boring #: VW-3 (Pg 1/2)
Drilling Method: Auger	Rig Type: Rotary	Date: 4/1/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	USCS	Sample description
0			Drilling w/ solid stem augers; Sampling w/ split spoons driven by gas power pneumatic hammer
1	SS-1 (1.0-3.0ft) rec. 100%		
2		SP	sd. fn-md grnd, dk brn, silty, intermittent gravel qtz-sis grnd, moderate sorting
3		SW	sd; m grnd poor sorted, trace gravel; mottled w/ iron stains slightly moist.
5		SP	. med brn; some gravel, qtzic, subangular. gravel is white qtz - angular 1/2-3/4" diameter
7		SP	sand, fine-med grained, med-light brown; moist quartzic; dark brown interval w/ feldspar gravels 1/2-1 in diam
8		SP	sand, med to coarse grained; well sorted; mottled w/ rust brown matrix is buff to white
9.5		SP	buff to lite brown; coarse grained, qtzic, sub rounded large gravels 1.5" diameter feldspars; moist; no odor
11		SW	coarse grained; fair sorting quartzic; subrounded slightly moist; no odor
13		SW	poorly sorted w/ much v. large gravel up to 1.7" diameter gravels are quartz feldspars; some are iron stained.
14		SG	sand is very coarse grained & poorly sorted; grl feldspar
15		SG	sand finer grained (med grnd) lighter color (buff) gravel 1-1.5 inches diameter, sand subrounded
16		SW	some silt/clay; medium brown; some very large gravels well graded; coarsening downward; some clay pockets no odor
17		SG	sand is coarse grnd, quartzic poorly sorted. Med brown gravels 1" diam, qtze maybe cherty
18		SG	(as above); trace of silt; poorly sorted; grls 1/4-1"
19		SG	(as above); trace silt; gravel as above
20			No odors of fuel to this depth

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BORING LOG

Project #: G-002737-01	Site: Rhein Main AB POL Yard	Boring #: VW-3 (Pg 2/2)
Drilling Method: Auger	Rig Type: Rotary	Date: 4/1/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Terry

Depth (feet bgs)	Sample ID	USCS	Sample description
20		SG	(as above) trace silt; gravels subrounded 1/4-1" diam
21			hit groundwater at about 21 ft. - run conductor (6 1/2" casing) downhole and start to "pump" sediment out of hole
22			
23		SP	sand well sorted; medium-fine grained, quartzic subrounded; no gravel; wet (below gwt); NO ODOR
24		SP	sand, coarse grained, quartzic w/feldspar; subrounded wet; NO ODOR; some v. small gravel (< 1/8")
25			No Recovery except 1/2" silty med-grey clayey "plug"
26		SP	Med → cs grained; subrounded; NO ODOR
27		SW	course grained; no fines; trace gravel (~1" feld) quartzic, subrounded SLIGHT ODOR
28		CL	clay, mottled brown-med grey @ top grading to lt. grey stiff dense, silty at top; v. clayey at bottom
29			
30			TOTAL DRILLED DEPTH 29.5 ft.
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

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BORING LOG

Project #: G002737-01	Site: Rhein Main AB POL Yard	Boring #: VW-4
Drilling Method: Auger/Split Spoon	Rig Type: Rotary	Date: 4/5/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	USCS	Sample description
0			Note: Many intervals in this borehole were not logged, rather samples were collected in brass sleeves and sent to laboratory for inorganic analyses or grain size distribution analyses.
6		SP	Sand; med-lt brown; med-cs grained; fair sorting
9–10			No log
12–14		SG	Sand, gravely, fair sorting; quartz; med-cs grained buff & pink color; gravels 1/8-1" diameter; no odor
18–20		SG	Sand, gravely, cs grained; lite gray/buff, moderate sorting; qtz subrounded; gravel <1/8-1/2" diam subrounded, quartzite

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BORING LOG

Project #: G002737-01	Site: Rhein Main AB POL Yard	Boring #: VW-4
Drilling Method: auger	Rig Type: Rotary	Date: 4/5/96
Drilling Contractor: Roltis	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	USCS	Sample description
20			
21		SG	Sand, gravely; coarse grained; moderate sorting, gravels 1/8 - >1" diam; subrounded
22			
23		SP	Sand; med grained, lite gray; well sorted
24			
25		SP	Sand; med grained, qtzic, sli odor
26		SP	Sand; med grained; some silt; qtzic, subrounded, med - lite gray
27			
28		SP	Sand; cs grained; moderate sorting, qtzic, med grey; gravels 1/8 - 1½" diameter; subrounded
29			GOOD FUEL ODOR
30		SP	Sand; as above but less gravel; med - lite gray
31			Total depth 31.17 ft.
32			
33			
34			
35			
36			
37			
38			
39			
40			

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BORING LOG

Project #: G002737-01	Site: Rhein Main POL Yard	Boring #: MW-1
Drilling Method: auger / split spoon	Rig Type: Rotary	Date: 4/10/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	Blow Counts	USCS	Sample description	OVA (ppm)	TPH (ppm)
0						
1			CL	clay, silty (20%); dark brown, stiff, gravelly silt below		
2			SP	(med brown); gravel 1/8-1" diam; subrounded); sand 30%		
3			SP	; sand, fine grained, dark brown, abrupt change to med-grained; qtz,		
4						
5			SP	; sand; fine-med grained, lite brown; abrupt grain size change to med grained; sl darker FUEL ODOR		
6			SW	abrupt change to coarse grained sand at 6'		
7			SW	gravelly at 7'; med-light brown, subrounded SLIGHT ODOR		
8			SW	finer grained at 8', some gravel, as above		
9			SP	med grained; med brown color lighten downward FUEL ODOR		
10			SP/SC	sand as above but some clay		
11			SC	clayey sand - grey w/sand matrix FAINT ODOR		
12			SW	coarse to fine grained; sli gravelly (1/4-3/4") poorly sorted		
13						
14			SW	sand; very rubbley - gravel; soft lenses med grained; dk grey to black VERY SLIGHT FUEL ODOR		
15				qtz gravel (1/8-1 1/2" diameter)		
16			SM/SW	sand; med-cs grained; silty; fair grading. Rubbley as above, cs grnd, well rounded		
17				clay/silt 20-35% each gravel 30% (1/8-1" diam)		
18			SP	finer grained than above, med gray color		
19			SP	fine grained; moderate sorting; some brown mottling - darker grey than above NO ODOR		
20						

BHGRM01.CDR

Battelle
. . . Putting Technology To Work

BORING LOG

Project #: G002737-01	Site: Rhein Main AB POL Yard.	Boring #: MW-1
Drilling Method: Augur / split spoon	Rig Type: Rotary	Date: 4/10/96
Drilling Contractor: Rolig	Driller:	Hydrogeologist: CJ Perry

Depth (feet bgs)	Sample ID	Blow Counts	USCS	Sample description	OVA (ppm)	TPH (ppm)
20			SP	med-cs grained; lite-med gray. FAINT ODOR		
21				cs grained; well rounded; qtzic, lite gray; wet FUEL ODOR		
22			SP	slightly fine grained than above		
23			SP	med-lt brown. cs grained, well srted 25% silt veins / globs & gravel FAINT ODOR, wet		
24						
25			SP	Brown; med-cs grained SLIGHT ODOR		
26			SW	fine-medium grained; stiff; clayey & silty SLIGHT ODOR		
27				DRILLED FROM 27.0 to 34.5 ft. (10.5 m)		
28				using gravel pump & augers. — no sampling		
29						
30				TOTAL DEPTH: 34.5' (10.5 M)		
31						
32						
33						
34						
35						
36						
37						
38						
39						
40						

BHGRM01.CDR

APPENDIX C

SURFACE EMISSIONS SAMPLING RESULTS

SURFACE EMISSIONS RESULTS

APRIL 1996

Rhein–Main AB Germany Surface Emission Results
Sampling Period: 4/08/96 to 4/10/96

SAMPLE CONCENTRATIONS

Tube ID	Site ID	Benzene (ppbv)	Toluene (ppbv)	Ethyl Benzene (ppbv)	m&p Xylene (ppbv)	o–Xylene (ppbv)	TPH as Hexane (ppbv)
A–11	RM1–Center–1	1.30	1.59	<0.50	0.56	<0.50	34.07
A–24	RM1–Center–2	1.37	2.46	<0.50	0.79	<0.50	212.19
A–27	RM1–Center–3	1.08	1.08	<0.50	<0.50	<0.50	222.05
A–26	RM1–Perimeter–1	1.26	2.79	<0.50	0.96	n.d.	329.86
A–1	RM1–Perimeter–2	1.10	0.84	<0.50	<0.50	<0.50	39.03
A–25	RM1–Perimeter–3	0.62	0.59	<0.50	<0.50	<0.50	25.55
A–14	RM1–Background–1	<0.50	0.72	<0.50	<0.50	n.d.	294.15
A–20	RM1–Background–2	0.67	0.71	<0.50	<0.50	n.d.	35.37
A–16	RM1–Atmosphere	1.56	2.82	n.d.	0.59	<0.50	218.41
A–28	RM1–Cylinder	0.64	<0.50	n.d.	<0.50	n.d.	23.57
A–19	RM1–Trip Blank	<0.50	<0.50	n.d.	<0.50	n.d.	14.11

<0.50 = Below Method Detection Limit.
n.d. = Not Detected.

FLUX RATES: ug/ 0.453 m²/minute.

Tube ID	Site ID	Benzene	Toluene	Ethyl Benzene	m&p Xylene	o–Xylene	TPH as Hexane
A–11	RM1–Center–1	0.008	0.012	<0.004	0.005	<0.004	0.245
A–24	RM1–Center–2	0.009	0.018	<0.004	0.007	<0.004	1.524
A–27	RM1–Center–3	0.007	0.008	<0.004	<0.004	<0.004	1.595
A–26	RM1–Perimeter–1	0.008	0.021	<0.004	0.008	n.d.	2.369
A–1	RM1–Perimeter–2	0.007	0.006	<0.004	<0.004	<0.004	0.280
A–25	RM1–Perimeter–3	0.004	0.004	<0.004	<0.004	<0.004	0.183
A–14	RM1–Background–1	<0.004	0.005	<0.004	<0.004	n.d.	2.112
A–20	RM1–Background–2	0.004	0.005	<0.004	<0.004	n.d.	0.254
A–16	RM1–Atmosphere	0.010	0.021	n.d.	0.005	<0.004	1.568
A–28	RM1–Cylinder	0.004	<0.004	n.d.	<0.004	n.d.	0.169
A–19	RM1–Trip Blank	<0.004	<0.004	n.d.	<0.004	n.d.	0.101

<0.004 = Below Method Detection Limit.
n.d. = Not Detected.

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ______

Proj. No.	Project Title
G002737-01	Rhein-Main AB, POL Yard

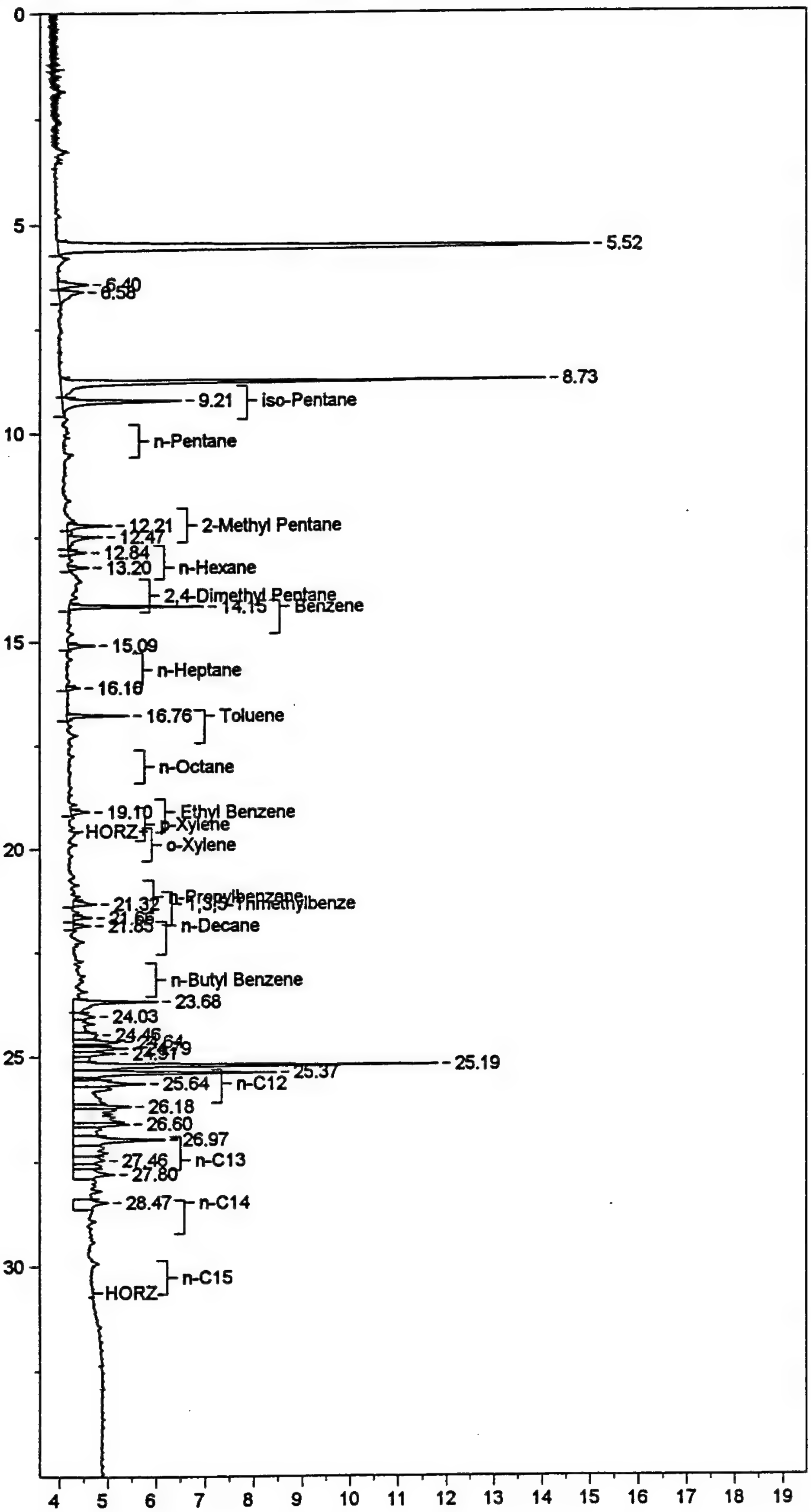
SAMPLERS: (Signature) Chris Perry, Walter Siebenlist

DATE	TIME	SAMPLE I.D.	SAMPLE TYPE (√) BTEX/TPH	Organics tip			Container No.	Number of Containers	Remarks
4.8.96	10^{10}	RMI-ATMOSPHERE	✓		A-16	13		1	Sorbent Tube
4.8.96	11^{30}	RMI-CENTER-1	✓		A-11	9		"	" "
4.8.96	11^{37}	RMI-CENTER-2	✓		A-24	10		"	" "
4.8.96	11^{45}	RMI-CENTER-3	✓		A-27	11		"	" "
4.8.96	11^{55}	RMI-CYLINDER	✓		A-28	12		"	" "
4.8.96	15^{22}	RMI-PERIMETER-1	✓		A-26	6		"	" "
4.8.96	15^{29}	RMI-PERIMETER-2	✓		A-1	7		"	" "
4.8.96	15^{36}	RMI-PERIMETER-3	✓		A-25	8		"	" "
4.10.96	14^{36}	RMI-BACKGROUND-1	✓		A-14	4			
4.10.96	14^{43}	RMI-BACKGROUND-2	✓		A-20	5			
4.10.96	15^{00}	RMI-TRIP BLANK	✓		A-19	1			

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
J. Kramer	4.10.96 15^{30}	A Pollard 4-11-96	Al Pollard	4-15-96 0900 hr	

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks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6.40
6.58
8.73
9.21
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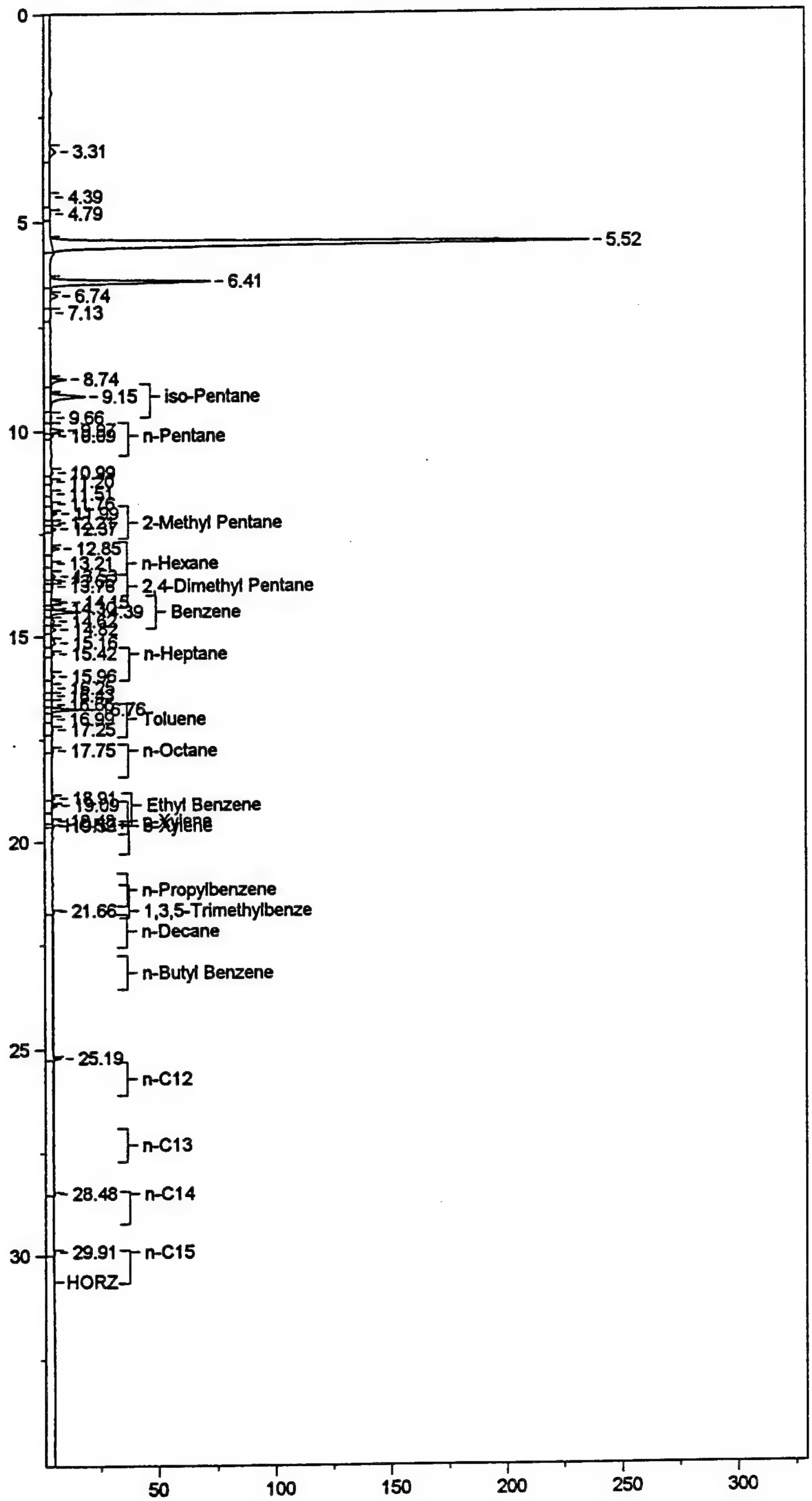
n-Pentane
12.21
12.47
2-Methyl Pentane
12.84
13.20
n-Hexane
2,4-Dimethyl Pentane
14.15
Benzene
15.09
n-Heptane
16.16
16.76
Toluene
n-Octane
19.10
Ethyl Benzene
HORZ
p-Xylene
o-Xylene
n-Propylbenzene
21.32
1,3,5-Trimethylbenze
21.66
21.85
n-Decane
n-Butyl Benzene
23.68
24.03
24.46
24.64
24.79
24.91
25.19
25.37
25.64
n-C12
26.18
26.60
26.97
27.46
n-C13
27.80
28.47
n-C14
n-C15
HORZ
0
5
10
15
20
25
30
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

Sample Name: **GERTUBE A-28 CYLINDER 300CC**
Acquired from HP5890--FID via Port 3 on 04-14-1996 09:49:44
HP5890 FID G002737-01
300CC SWEEP
Data File: **C:\CPWIN\DATA1\RHEINAFB.04R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	5.519		5.2535	28.267	75198.5	28.691	BB	0.114	11028.49	19.936
2	6.405		0.2368	1.274	3390.2	1.293	BV	0.090	628.91	1.137
3	6.583		0.2951	1.588	4223.8	1.612	VB	0.137	512.12	0.926
4	8.735		2.8534	15.353	40843.2	15.583	BV	0.068	10051.39	18.169
5	9.208	iso-Pentane	0.9593	5.162	12708.4	4.849	VB	0.086	2459.97	4.447
6	12.209	2-Methyl Pentane	0.2529	1.361	3513.7	1.341	BV	0.064	911.25	1.647
7	12.469		0.2440	1.313	3492.9	1.333	VB	0.082	713.06	1.289
8	12.842		0.0892	0.480	1276.2	0.487	BB	0.059	361.43	0.653
9	13.203	n-Hexane	0.0947	0.510	1356.1	0.517	BB	0.055	413.93	0.748
10	14.148	Benzene	0.4754	2.558	8593.9	3.279	BB	0.052	2775.59	5.017
11	15.086		0.1419	0.764	2031.7	0.775	BB	0.062	550.40	0.995
12	16.099		0.0668	0.360	956.8	0.365	BB	0.057	281.50	0.509
13	16.763	Toluene	0.2308	1.242	4116.1	1.570	BB	0.054	1282.24	2.318
14	19.097	Ethyl Benzene	0.0672	0.362	1490.3	0.569	BB	0.066	378.95	0.685
15	21.325	1,3,5-Trimethylbenze	0.1045	0.562	2172.0	0.829	BB	0.074	487.75	0.882
16	21.657		0.0998	0.537	1428.3	0.545	BV	0.062	385.87	0.698
17	21.846	n-Decane	0.0502	0.270	1143.3	0.436	VB	0.054	350.14	0.633
18	23.675		0.5132	2.761	7345.7	2.803	BV	0.075	1638.48	2.962
19	24.029		0.1166	0.627	1669.3	0.637	VV	0.087	318.77	0.576
20	24.460		0.1852	0.996	2650.5	1.011	VV	0.125	354.49	0.641
21	24.638		0.2575	1.386	3686.2	1.406	VV	0.077	797.08	1.441
22	24.790		0.2731	1.470	3909.4	1.492	VV	0.069	948.10	1.714
23	24.914		0.2045	1.100	2927.4	1.117	VV	0.072	680.33	1.230
24	25.195		1.8888	10.163	27036.1	10.315	VV	0.062	7326.21	13.243
25	25.373		1.1477	6.175	16427.5	6.268	VV	0.069	3957.32	7.153
26	25.641	n-C12	0.4035	2.171	6926.2	2.643	VV	0.092	1252.14	2.263
27	26.178		0.2635	1.418	3772.2	1.439	VV	0.068	920.88	1.665
28	26.600		0.2483	1.336	3553.6	1.356	VV	0.069	853.01	1.542
29	26.969		0.5835	3.140	8352.5	3.187	VV	0.089	1565.09	2.829
30	27.458	n-C13	0.1983	1.067	1799.0	0.686	VV	0.106	283.34	0.512
31	27.796		0.1643	0.884	2351.2	0.897	VB	0.082	475.28	0.859
32	28.473	n-C14	0.6217	3.345	1755.4	0.670	BB	0.078	376.95	0.681

? isobutane
2 methyl 1-Butene

Total Area = 262097.4, Total Amount = 18.585, Total Height = 55320.48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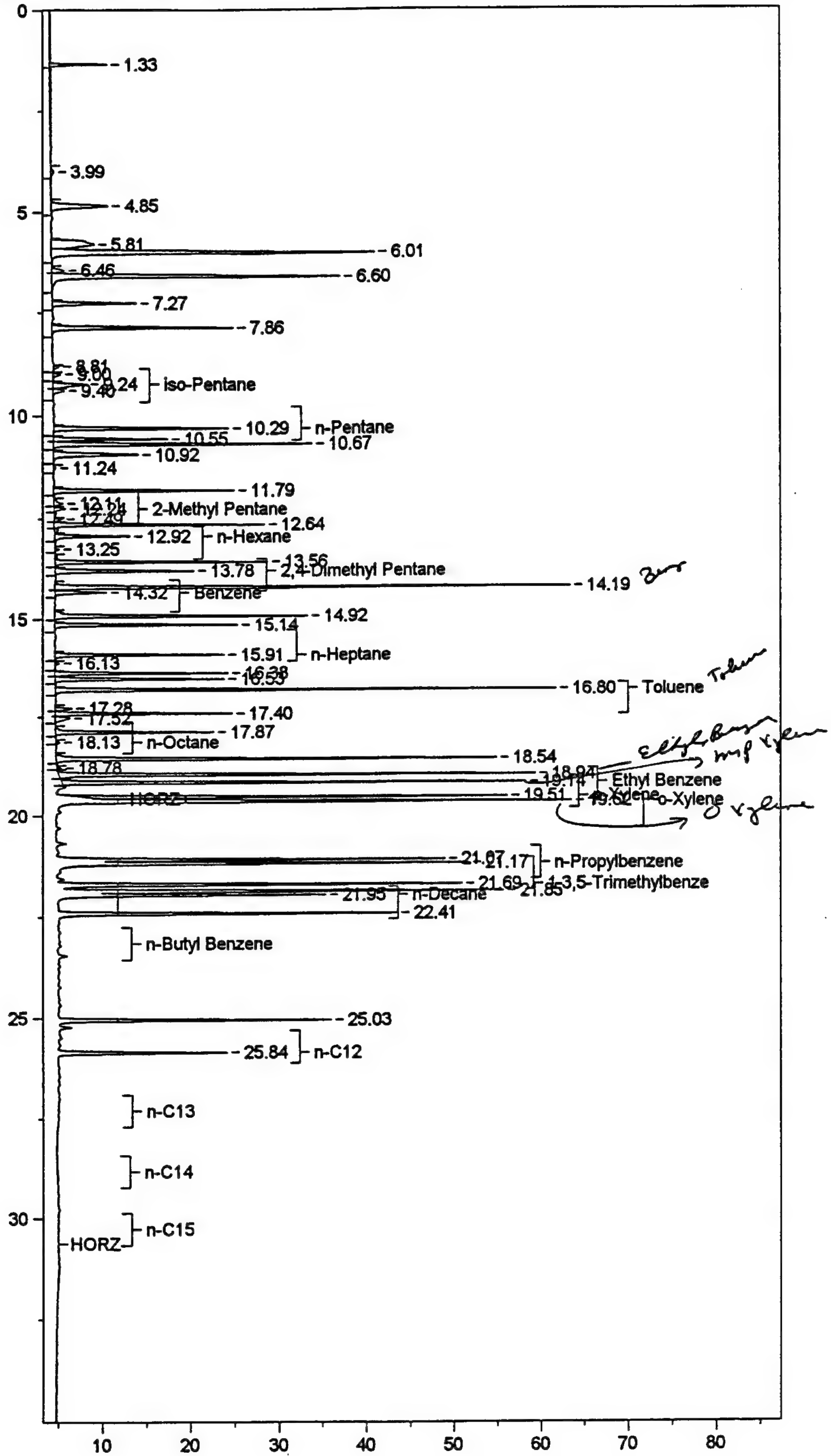
4.39
4.79
5.52
6.41
6.74
7.13
8.74
9.15
iso-Pentane
9.66
n-Pentane
2-Methyl Pentane
12.37
12.85
13.21
n-Hexane
13.98
2,4-Dimethyl Pentane
Benzene
15.42
n-Heptane
15.96
Toluene
17.25
17.75
n-Octane
Ethyl Benzene
n-Propylbenzene
21.66
1,3,5-Trimethylbenze
n-Decane
n-Butyl Benzene
25.19
n-C12
n-C13
28.48
n-C14
29.91
n-C15
HORZ
0
5
10
15
20
25
30
50
100
150
200
250
300

Sample Name: **GERTUBE A-16 ATMOSPHERE 300CC**
Acquired from HP5890--FID via Port 3 on 04-14-1996 11:11:02
HP5890 FID G002737-01
300CC SWEEP
Data File: **C:\CPWIN\DATA1\RHEINAFB.05R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	3.313		1.4250	0.833	20397.2	0.840	BB	0.140	2436.40	0.604
2	4.386		0.1155	0.068	1653.5	0.068	BB	0.103	268.81	0.067
3	4.793		0.1127	0.066	1613.5	0.066	BB	0.094	285.41	0.071
4	5.517		115.0667	67.275	1647054.0	67.811	BB	0.118	231716.00	57.484
5	6.412		24.5013	14.325	350709.8	14.439	BV	0.085	68796.24	17.067 – 1-Butene
6	6.739		1.2815	0.749	18343.1	0.755	VV	0.094	3241.48	0.804
7	7.131		0.2262	0.132	3237.9	0.133	VB	0.158	342.52	0.085
8	8.742		1.7806	1.041	25487.7	1.049	BV	0.064	6591.93	1.635
9	9.152	iso-Pentane	5.9925	3.504	79383.7	3.268	VB	0.089	14897.99	3.696
10	9.663		0.1696	0.099	2427.2	0.100	BB	0.103	394.08	0.098
11	9.970		1.5149	0.886	21684.5	0.893	BV	0.066	5473.09	1.358
12	10.095	n-Pentane	0.3340	0.195	3686.5	0.152	VB	0.060	1028.76	0.255
13	10.988		0.2502	0.146	3581.5	0.147	BB	0.075	796.66	0.198
14	11.203		0.0867	0.051	1241.2	0.051	BB	0.061	339.79	0.084
15	11.513		0.0867	0.051	1241.6	0.051	BV	0.062	336.22	0.083
16	11.757		0.1700	0.099	2433.9	0.100	VV	0.062	652.42	0.162
17	11.987		0.7138	0.417	10217.0	0.421	VV	0.075	2274.92	0.564
18	12.213	2-Methyl Pentane	0.1908	0.112	2650.9	0.109	VV	0.055	796.11	0.197
19	12.369		0.5000	0.292	7157.2	0.295	VB	0.068	1743.89	0.433
20	12.847		0.8104	0.474	11600.1	0.478	BV	0.060	3217.05	0.798
21	13.206	n-Hexane	0.1067	0.062	1527.9	0.063	VV	0.060	425.83	0.106
22	13.530		0.6679	0.391	9560.7	0.394	VV	0.092	1735.03	0.430
23	13.651		0.1649	0.096	2360.4	0.097	VV	0.078	502.81	0.125
24	13.760	2,4-Dimethyl Pentane	0.2640	0.154	3400.1	0.140	VV	0.093	607.19	0.151
25	14.149		1.4656	0.857	20977.8	0.864	VV	0.052	6752.18	1.675
26	14.296		0.2875	0.168	4114.7	0.169	VV	0.063	1093.49	0.271
27	14.392	Benzene	2.5764	1.506	46572.3	1.917	VV	0.061	12778.63	3.170
28	14.619		0.5566	0.325	7967.4	0.328	VV	0.095	1396.74	0.347
29	14.823		0.6262	0.366	8963.5	0.369	VV	0.080	1875.65	0.465
30	15.156		0.8288	0.485	11863.8	0.488	VB	0.112	1770.26	0.439
31	15.416	n-Heptane	0.2264	0.132	3849.6	0.158	BB	0.055	1171.28	0.291
32	15.961		0.4091	0.239	5855.2	0.241	BV	0.070	1401.36	0.348
33	16.251		0.1858	0.109	2659.7	0.110	VB	0.091	488.09	0.121
34	16.432		0.0947	0.055	1355.6	0.056	BV	0.061	371.36	0.092
35	16.648		0.1818	0.106	2602.4	0.107	VV	0.103	419.57	0.104
36	16.763		2.9181	1.706	41768.8	1.720	VV	0.051	13715.86	3.403
37	16.987	Toluene	0.0873	0.051	1557.4	0.064	VB	0.076	341.67	0.085
38	17.246		0.1918	0.112	2745.3	0.113	BB	0.099	464.05	0.115
39	17.753	n-Octane	0.1232	0.072	2355.2	0.097	BB	0.052	756.34	0.188
40	18.911		0.3107	0.182	4446.9	0.183	BV	0.053	1400.79	0.348
41	19.093	Ethyl Benzene	0.4040	0.236	8958.2	0.369	VB	0.067	2235.77	0.555
42	19.477	p-Xylene	0.0698	0.041	1268.7	0.052	BB	0.053	401.94	0.100

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
43	19.591	o-Xylene	0.0592	0.035	1250.6	0.051	BB	0.034	615.74	0.153
44	21.663	1,3,5-Trimethylbenze	0.0895	0.052	1861.3	0.077	BV	0.063	491.20	0.122
45	25.194		0.6660	0.389	9533.3	0.392	VV	0.051	3135.59	0.778
46	28.475	n-C14	0.5492	0.321	1550.4	0.064	VB	0.043	603.42	0.150
47	29.909	n-C15	1.5981	0.934	2162.8	0.089	BB	0.070	513.01	0.127

Total Area = 2428892.0, Total Amount = 171.039, Total Height = 403094.6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4.85
5.81
6.01
6.46
6.60
7.27
7.86
8.81
9.00
9.24
9.40
iso-Pentane
10.29
n-Pentane
10.55
10.67
10.92
11.24
11.79
12.11
12.24
12.49
2-Methyl Pentane
12.64
12.92
n-Hexane
13.25
13.56
13.78
2,4-Dimethyl Pentane
14.19
Benz
14.32
Benzene
14.92
15.14
15.91
n-Heptane
16.13
16.38
16.53
16.80
Toluene
Toluen
17.28
17.40
17.52
17.87
18.13
n-Octane
18.54
Ethyl Benzen
m+p Xylene
18.78
18.94
19.14
Ethyl Benzene
19.51
p-Xylene
19.62
o-Xylene
O Xylene
HORZ
21.07
21.17
n-Propylbenzene
21.69
21.85
1,3,5-Trimethylbenze
21.95
n-Decane
22.41
n-Butyl Benzene
25.03
25.84
n-C12
n-C13
n-C14
n-C15
HORZ
0
5
10
15
20
25
30
10
20
30
40
50
60
70
80

Sample Name: **GERTUBE 42COMP 10PPBC 17305 300CC**
Acquired from HP5890--FID via Port 3 on 04-15-1996 08:39:15
HP5890 FID G002737-01
300CC SWEEP
Data File: **C:\CPWIN\DATA1\RHEINAFB.14R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	1.330		1.1963	0.549	17124.3	0.508	BB	0.044	6498.69	0.602
2	3.989		0.1980	0.091	2834.2	0.084	BB	0.141	335.18	0.031
3	4.847		2.7350	1.255	39148.9	1.161	BB	0.101	6451.72	0.597
4	5.811		3.4324	1.575	49131.5	1.457	BV	0.169	4843.22	0.449
5	6.009		12.1287	5.565	173609.4	5.149	VV	0.079	36686.23	3.397
6	6.457		0.4755	0.218	6805.7	0.202	VV	0.081	1402.27	0.130
7	6.597		9.9332	4.558	142183.1	4.217	VV	0.072	32722.09	3.030
8	7.267		2.3920	1.098	34238.6	1.016	VB	0.060	9580.05	0.887
9	7.860		5.2145	2.393	74639.9	2.214	BB	0.061	20532.31	1.901
10	8.808		0.1486	0.068	2126.6	0.063	BB	0.060	594.75	0.055
11	8.997		0.2185	0.100	3127.2	0.093	BV	0.062	843.82	0.078
12	9.237	iso-Pentane	1.3954	0.640	18485.4	0.548	VV	0.081	3806.15	0.352
13	9.395		0.4184	0.192	5988.4	0.178	VB	0.080	1246.11	0.115
14	10.295	n-Pentane	6.0212	2.763	66451.8	1.971	BB	0.056	19818.16	1.835
15	10.547		2.5278	1.160	36183.1	1.073	BV	0.046	12972.23	1.201
16	10.671		6.4505	2.960	92331.6	2.739	VV	0.052	29316.01	2.715
17	10.922		3.0682	1.408	43917.7	1.303	VV	0.076	9625.88	0.891
18	11.238		0.0828	0.038	1185.4	0.035	VB	0.078	253.05	0.023
19	11.792		4.6534	2.135	66607.9	1.976	BV	0.054	20464.99	1.895
20	12.109		0.3394	0.156	4858.1	0.144	VV	0.077	1046.46	0.097
21	12.241	2-Methyl Pentane	0.3616	0.166	5024.1	0.149	VV	0.063	1337.48	0.124
22	12.491		0.2211	0.101	3164.5	0.094	VV	0.057	917.43	0.085
23	12.635		4.8865	2.242	69944.2	2.075	VV	0.049	23825.77	2.206
24	12.920	n-Hexane	1.9446	0.892	27834.1	0.826	VV	0.055	8511.33	0.788
25	13.251		0.1106	0.051	1583.0	0.047	VV	0.056	468.08	0.043
26	13.558		5.0023	2.295	71603.0	2.124	VV	0.050	24103.73	2.232
27	13.784	2,4-Dimethyl Pentane	4.4180	2.027	56890.9	1.687	VB	0.060	15696.15	1.454
28	14.185		12.5642	5.765	179843.1	5.334	BV	0.051	58724.11	5.438
29	14.322	Benzene	1.1614	0.533	20994.2	0.623	VB	0.060	5861.59	0.543
30	14.915		6.5873	3.023	94290.0	2.797	BV	0.055	28668.52	2.655
31	15.137		4.4040	2.021	63037.9	1.870	VB	0.051	20718.72	1.919
32	15.909	n-Heptane	3.2994	1.514	56104.0	1.664	BV	0.049	19196.59	1.778
33	16.127		0.1356	0.062	1940.8	0.058	VB	0.066	486.88	0.045
34	16.385		3.8054	1.746	54469.8	1.616	BV	0.046	19589.00	1.814
35	16.531		4.0039	1.837	57311.2	1.700	VV	0.050	19143.35	1.773
36	16.798	Toluene	9.5509	4.383	170357.2	5.053	VB	0.050	57026.97	5.281
37	17.279		0.4567	0.210	6536.7	0.194	BV	0.057	1912.11	0.177
38	17.402		4.0718	1.868	58283.0	1.729	VV	0.049	19989.17	1.851
39	17.524		0.5519	0.253	7899.7	0.234	VB	0.081	1624.85	0.150
40	17.874		3.8518	1.767	55134.3	1.635	BB	0.051	17915.54	1.659
41	18.129	n-Octane	0.0604	0.028	1153.6	0.034	BB	0.046	415.05	0.038
42	18.542		10.4282	4.785	149267.7	4.427	BV	0.050	50128.95	4.642

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
43	18.777		0.1134	0.052	1622.7	0.048	VB	0.053	512.35	0.047
44	18.943		11.4376	5.248	163717.0	4.856	BV	0.050	54260.71	5.025
45	19.143	Ethyl Benzene	6.9459	3.187	154005.7	4.568	VB	0.049	52839.66	4.893
46	19.506	p-Xylene	7.2311	3.318	131366.2	3.896	BB	0.045	48491.91	4.491
47	19.621	o-Xylene	7.5754	3.476	159901.3	4.743	BB	0.051	52189.34	4.833
48	21.072		6.8195	3.129	97614.4	2.895	BV	0.043	37727.20	3.494
49	21.174	n-Propylbenzene	4.9900	2.290	111164.8	3.297	VB	0.046	40682.14	3.767
50	21.688	1,3,5-Trimethylbenze	4.9909	2.290	103743.6	3.077	BB	0.044	39412.09	3.650
51	21.854		8.9700	4.116	128395.7	3.808	BB	0.048	44590.38	4.129
52	21.952	n-Decane	2.5836	1.186	58801.9	1.744	BV	0.040	24378.30	2.258
53	22.409		5.6176	2.578	80409.1	2.385	VB	0.041	32493.34	3.009
54	25.032		4.0524	1.860	58006.3	1.720	BB	0.040	24295.76	2.250
55	25.842	n-C12	1.6967	0.779	29121.7	0.864	BB	0.038	12692.32	1.175

Total Area = 3371516.0, Total Amount = 217.931, Total Height = 1079866.0

Dec 29, 1993

Multipliers to generate the ppb C values for TPH

2.64 ppb ϕ = 15.84 ppb Carbon

$\bar{X}$ area for 500 cc sample = $\frac{15810}{15.84}$ = 998.11 area counts per ppb C.

∴ divide the TPH area / 998.11 to generate the ppbC value

To multiply PPBU x (x) to get Flux Values of µg Compound / .453 m²/min

Benzene mult = 0.00640

Toluene mult. = 0.00752

Ethyl Benzene mult. = 0.00868

m/p Xylene mult. = 0.00868

o xylene mult = 0.00869

TPH (as Hexane) mult = 0.007181

RT's	14.19 min	16.80 min	18.94	mp 19.13 / o xylene 19.62	
Sample/Tube	Benzene area/ppb	Toluene	E Benz.	m,p / o xylene	TPH
[illegible] 1/A11	17471.8	23574.3	4120.7	8595.0 / 1031.7	378925.4
	~~0.13~~ 1.30 ppbv	1.59	0.28	0.56 / 0.15	34.07
[illegible] 2/A24	18429.8	36378.6	4735.9	12006.5 / 1308.3	2359685.0
	1.37	2.46	0.32	0.79 / 0.19	212.19
[illegible] 3/A27	14477.8	16028.1	2788.1	5620.2 / 632.5	2469343.[illegible]
	1.08	1.08	0.19	0.37 / 0.09	222.05
[illegible] 1/A26	16913.8	41399.1	4526.5	14709.2 / ND	3668298.0
	1.26	2.79	0.31	0.96 / —	329.86
[illegible] 4/A-1	14761.4	12454.2	1932.3	3901.2 / 2871.7	434074.8
	1.10	0.84	0.13	0.26 / 0.43	39.03
[illegible] 3/A-25	8311.5	8738.0	1167.6	2779.8 / 748.0	284133.3
	0.62	0.59	0.08	0.18 / 0.11	25.55
[illegible] 1/A14	6561.7	10642.5	1574.0	3611.1 / ND	3,271,137.0
	0.49	0.72	0.11	0.24 / —	294.15
[illegible] 2/A20	9009.4	10560.0	1449.5	4486.0 / ND	393,334.8
	0.67	0.71	0.10	0.29 / —	35.37
[illegible] blank/A-19	2744.4	2496.4	ND ~~[illegible]~~	1837.3 / ND	156962.6 ~~[illegible]~~
	0.20	0.17	—	0.12 / —	14.11
[illegible]/A23	8593.3	4116.1	ND	1490.3 / ND	262097.4
	0.64	0.28	—	0.10 / —	23.57
[illegible]/A16	20977.8	41768.8	ND	8958.2 / 1250.6	2428892.0
	1.56	2.82	—	0.59 / 0.19	218.41
	1	2	3	4	5
-14/300cc	179843.1	170357.2	163717.0	154005.7	(159901.3 x.8)
[illegible]	13.40	11.50	11.20	10.10	19.0

Cu

SURFACE EMISSIONS RESULTS

OCTOBER 1996

Analytical Technique for Processing the Sorbent Sampling Tubes

The organic compounds retained by the sorbent materials in the sampling tubes were thermally desorbed, refocused, and analytically resolved using gas chromatography. A calibration mixture that contained the compounds of interest was processed to establish these retention times and response factors. Generally, the same volume sample as that collected during the soil emission sampling was used when processing the calibration gas.

Instrumentation

The instrumentation and analytical technique used to process the sorbent tubes was based upon the US EPA Method TO-14 that is employed to identify toxic organics in ambient air. This method involves: 1) the collecting of VOCs in a gas sample on a cryogenically cooled glass bead trap; 2) the transfer of the trapped organics by ballistically heating the cold trap, with; 3) the delivery of the organics to a GC for qualitative/quantitative analysis. The modification to the method when using sorbent tubes was the extra step of heating the tube to deliver the remotely collected organics to the cold, glass-bead trap.

The automated GC system consisted of a Hewlett-Packard Model 5890 GC with parallel flame ionization (FID) and electron capture (ECD) detectors. Hewlett Packard 3396A integrators in conjunction with a 9122 disk drive received detector output signals and stored data. The disk drive also provided access to the Basic program used to automate sample collection from the sorbent tube and analysis. A modified NuTech Model 320 sample preconcentration unit was used to collect the organics from the tube. The unit contained two subsystems: (1) an electronic console that regulated various temperature zones, and (2) the sample-handling subassembly containing a 6-port valve and trap. The console controlled the temperatures of the valve body (120°C), sample transfer lines (120°C), and the trap. The trap temperature was regulated by the controlled release of liquid nitrogen via a solenoid valve. The trap temperature during sample transfer from the sorbent tube was maintained at -150°C. The trap was heated to 130°C for delivery of organics to the GC.

Sample flow from the tube to the trap was controlled using: (1) a Tylan readout control unit, Model R032-B; (2) a Tylan zero to 100 standard cm^3/min mass flow controller, Model MFC-260; (3) a Thomas dual diaphragm pump; and (4) a Perma Pure Dryer, Model MD-125-48F. The readout control unit, in conjunction with the mass flow controller, regulated the sample transfer flow rate from the sorbent tube to the trap. The Perma Pure Dryer with a tubular hygroscopic ion-exchange membrane (Nafion) was used to selectively remove any water vapor from the sorbent sample. The Nafion tube size was 30 cm x 0.1 cm inner diameter, embedded within a shell of Teflon™ tubing of 0.25 cm inner diameter. A counter current flow of dry zero air (300 mL) was used to purge the shell. This type of dryer has been shown to have no affinity for BTEX or straight-chained/branched petroleum hydrocarbons (Pliel et al., 1987).

A Dynatherm, Model 10 sorbent tube conditioner/desorber was used to heat the sorbent tube to deliver the organics to the analytical system. A desorption temperature of 250°C with a helium purge gas flow of 20 mL/minute was used during the desorption process. The desorption time was 15 minutes, resulting in a total helium back-flush volume of 300 mL.

Calibration Mixture

The target compounds for TO-14 analysis are listed in Table 4. A calibration cylinder was prepared at Battelle that contained the 41 volatile organic compounds at a nominal targeted concentration of 200 ppbv for each species. A gas phase dynamic dilution system was used to generate the working calibration standard for the Eielson AFB tube analyses with species concentrations of 2 to 4 ppbv for each of the BTEX compounds. Separations chemistry of the TO-14 compounds was accomplished using two 30 m HP-1 series capillary columns joined with a zero dead-volume butt connector. Internal diameter of the capillary was 0.53 mm with a 2.65 μm film thickness. Optimal chromatographic resolution is obtained by temperature programming the GC oven from -50°C to 200°C at a rate of 8°C per minute.

The sampling tubes collected at Eielson AFB were processed using this system, with the FID area counts being used to calculate the compound concentration at each sampling location. The total FID area counts were used to generate the TPH value.

Rhein–Main AB Germany Surface Emission Results
Sampling Period: 10/30/96 to 11/01/96

SAMPLE CONCENTRATIONS

Tube ID	Site ID	Benzene (ppbv)	Toluene (ppbv)	Ethyl Benzene (ppbv)	m&p Xylene (ppbv)	o–Xylene (ppbv)	TPH as Hexane (ppbv)
Blower On	10/30/96						
A–7	RM1–Center–1	n.d.	<0.50	n.d.	n.d.	n.d.	9.30
A–8	RM1–Center–2	n.d.	0.66	n.d.	n.d.	n.d.	5.20
A–20	RM1–Perimeter–1	0.72	0.72	n.d.	n.d.	n.d.	2.05
A–21	RM1–Perimeter–2	n.d.	<0.50	n.d.	n.d.	n.d.	5.90
10/31/96							
A–17	RM1–Background–1	0.83	n.d.	n.d.	n.d.	n.d.	4.30
A–16	RM1–Background–2	<0.50	n.d.	n.d.	n.d.	n.d.	1.60
Blower Off	11/01/96						
A–12	RM1–Center–3	n.d.	n.d.	n.d.	n.d.	n.d.	22.33
A–23	RM1–Center–4	n.d.	n.d.	n.d.	n.d.	n.d.	2.90
A–3	RM1–Perimeter–3	n.d.	n.d.	n.d.	n.d.	n.d.	74.30
A–9	RM1–Perimeter–4	n.d.	n.d.	n.d.	n.d.	n.d.	14.10
A–18	RM1–Cylinder Air	n.d.	12.24	n.d.	n.d.	n.d.	53.55
A–28	RM1–Trip Blank	n.d.	n.d.	n.d.	n.d.	n.d.	25.70

<0.50 = Below Method Detection Limit.
n.d. = Not Detected.

FLUX RATES: ug/ 0.453 m²/minute.

Tube ID	Site ID	Benzene	Toluene	Ethyl Benzene	m&p Xylene	o–Xylene	TPH as Hexane
Blower On	10/30/96						
A–7	RM1–Center–1	n.d.	<0.005	n.d.	n.d.	n.d.	0.067
A–8	RM1–Center–2	n.d.	0.005	n.d.	n.d.	n.d.	0.037
A–20	RM1–Perimeter–1	0.005	0.005	n.d.	n.d.	n.d.	0.015
A–21	RM1–Perimeter–2	n.d.	<0.005	n.d.	n.d.	n.d.	0.042
10/31/96							
A–17	RM1–Background–1	0.005	n.d.	n.d.	n.d.	n.d.	0.031
A–16	RM1–Background–2	<0.005	n.d.	n.d.	n.d.	n.d.	0.011
Blower Off	11/01/96						
A–12	RM1–Center–3	n.d.	n.d.	n.d.	n.d.	n.d.	0.160
A–23	RM1–Center–4	n.d.	n.d.	n.d.	n.d.	n.d.	0.021
A–3	RM1–Perimeter–3	n.d.	n.d.	n.d.	n.d.	n.d.	0.534
A–9	RM1–Perimeter–4	n.d.	n.d.	n.d.	n.d.	n.d.	0.101
A–18	RM1–Cylinder Air	n.d.	0.093	n.d.	n.d.	n.d.	0.385
A–28	RM1–Trip Blank	n.d.	n.d.	n.d.	n.d.	n.d.	0.185

<0.005 = Below Method Detection Limit.
n.d. = Not Detected.

Rhein–Main AB Germany Surface Emission Results
Sampling Period: 10/30/96 to 11/01/96

SAMPLE CONCENTRATIONS

Tube ID	Site ID	Benzene (ppbv)	Toluene (ppbv)	Ethyl Benzene (ppbv)	m&p Xylene (ppbv)	o–Xylene (ppbv)	TPH as Hexane (ppbv)
Blower On	10/30/96						
A–7	RM1–Center–1	n.d.	<0.50	n.d.	n.d.	n.d.	9.30
A–8	RM1–Center–2	n.d.	0.66	n.d.	n.d.	n.d.	5.20
A–20	RM1–Perimeter–1	0.72	0.72	n.d.	n.d.	n.d.	2.05
A–21	RM1–Perimeter–2	n.d.	<0.50	n.d.	n.d.	n.d.	5.90
10/31/96							
A–17	RM1–Background–1	0.83	n.d.	n.d.	n.d.	n.d.	4.30
A–16	RM1–Background–2	<0.50	n.d.	n.d.	n.d.	n.d.	1.60
Blower Off	11/01/96						
A–12	RM1–Center–3	n.d.	n.d.	n.d.	n.d.	n.d.	22.33
A–23	RM1–Center–4	n.d.	n.d.	n.d.	n.d.	n.d.	2.90
A–3	RM1–Perimeter–3	n.d.	n.d.	n.d.	n.d.	n.d.	74.30
A–9	RM1–Perimeter–4	n.d.	n.d.	n.d.	n.d.	n.d.	14.10
A–18	RM1–Cylinder Air	n.d.	12.24	n.d.	n.d.	n.d.	53.55
A–28	RM1–Trip Blank	n.d.	n.d.	n.d.	n.d.	n.d.	25.70

<0.50 = Below Method Detection Limit.
n.d. = Not Detected.

FLUX RATES: ug/ 0.453 m²/minute.

Tube ID	Site ID	Benzene	Toluene	Ethyl Benzene	m&p Xylene	o–Xylene	TPH as Hexane
Blower On	10/30/96						
A–7	RM1–Center–1	n.d.	<0.005	n.d.	n.d.	n.d.	0.067
A–8	RM1–Center–2	n.d.	0.005	n.d.	n.d.	n.d.	0.037
A–20	RM1–Perimeter–1	0.005	0.005	n.d.	n.d.	n.d.	0.015
A–21	RM1–Perimeter–2	n.d.	<0.005	n.d.	n.d.	n.d.	0.042
10/31/96							
A–17	RM1–Background–1	0.005	n.d.	n.d.	n.d.	n.d.	0.031
A–16	RM1–Background–2	<0.005	n.d.	n.d.	n.d.	n.d.	0.011
Blower Off	11/01/96						
A–12	RM1–Center–3	n.d.	n.d.	n.d.	n.d.	n.d.	0.160
A–23	RM1–Center–4	n.d.	n.d.	n.d.	n.d.	n.d.	0.021
A–3	RM1–Perimeter–3	n.d.	n.d.	n.d.	n.d.	n.d.	0.534
A–9	RM1–Perimeter–4	n.d.	n.d.	n.d.	n.d.	n.d.	0.101
A–18	RM1–Cylinder Air	n.d.	0.093	n.d.	n.d.	n.d.	0.385
A–28	RM1–Trip Blank	n.d.	n.d.	n.d.	n.d.	n.d.	0.185

<0.005 = Below Method Detection Limit.
n.d. = Not Detected.

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. ____________

Proj. No. G00273701

Project Title RHEIN-MAIN AB. POL YARD

SAMPLERS: (Signature) WALTER SIEBENLIST

DATE	TIME	SAMPLE I.D.		BTEX	TPH (HEXANE Resp)	SAMPLE TYPE (√)	Container No.	Number of Containers	Remarks
10-30-96	12:00	RMI CENTER 1	11			Blower On		A 7	SORBENT TUB
10-30-96	12:15	RMI CENTER 2	12			Blower on		A 8	" "
10-30-96	14:45	RMI PERIMETER 1	9			Blower on		A 20	" "
10-30-96	15:00	RMI PERIMETER 2	10			Blower on		A 21	" "
10-31-96	14:36	RMI BACKGROUND 1	[illegible]					A 17	" "
10-31-96	15:00	RMI BACKGROUND 2	[illegible]					A 16	" "
11-1-96	8:00	RMI PERIMETER 3	3			Blower Off		A 3	" "
11-1-96	8:20	RMI PERIMETER 4	4			Blower off		A 9	" "
11-1-96	10:55	RMI CENTER 3	5			Blower off		A 12	" "
11-1-96	11:10	RMI CENTER 4	6			Blower off		A23	" "
11-1-96	11:20	RMI CYLINDER AIR	2	√	√			A 18	" "
11-1-96	11:40	RMI TRIP BLANK	0					A 28	" "

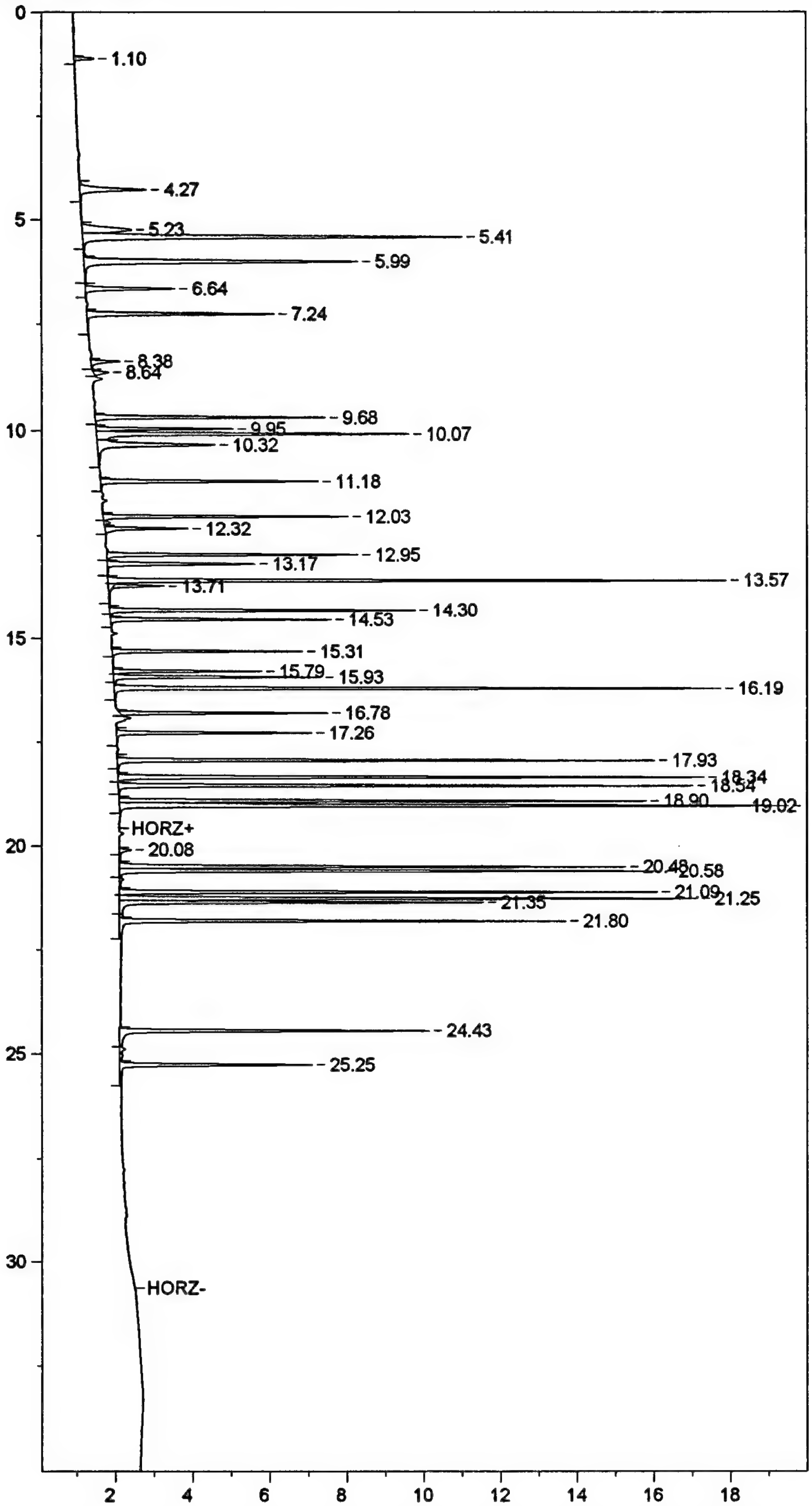
analytical Order

Relinquished by: (Signature)	Date/Time		Received by: (Signature)	Relinquished by: (Signature)	Date/Time		Received by: (Signature)
W Siebenlist	11-1-96	13:00	Al Pollard Nov 1, 1996 13:00 hr				

Relinquished by: (Signature)	Date/Time		Received by: (Signature)	Relinquished by: (Signature)	Date/Time		Received by: (Signature)

Relinquished by: (Signature)	Date/Time		Received for Laboratory by: (Signature)	Date/Time		Remarks

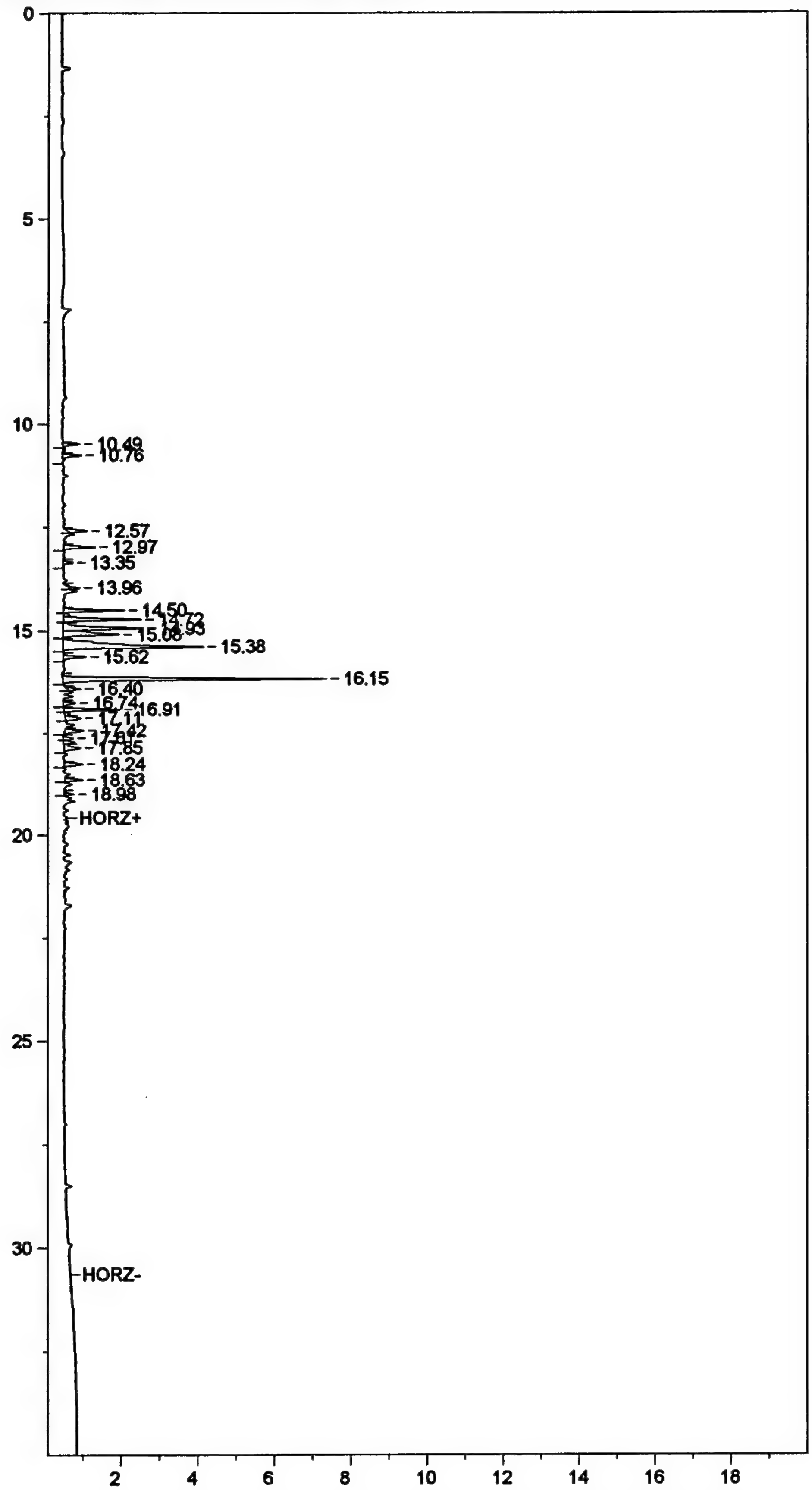
Page ____ of ____


1.10
4.27
5.23
5.41
5.99
6.64
7.24
8.38
8.64
9.68
9.95
10.07
10.32
11.18
12.03
12.32
12.95
13.17
13.57
13.71
14.30
14.53
15.31
15.79
15.93
16.19
16.78
17.26
17.93
18.34
18.54
18.90
19.02
HORZ+
20.08
20.48
20.58
21.09
21.25
21.35
21.80
24.43
25.25
HORZ-
0
5
10
15
20
25
30
2
4
6
8
10
12
14
16
18

Sample Name: **COMP42 20PPB 100/1000 300CC**
Acquired from HP5890--FID via Port 3 on 11-7-1996 12:45:41
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.14R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	1.104		0.0000	0.000	1975.8	0.190	BB	0.065	507.72	0.163
2	4.268		0.0000	0.000	10109.6	0.974	BB	0.097	1733.00	0.557
3	5.233		0.0000	0.000	9880.3	0.952	BV	0.128	1283.44	0.412
4	5.407		0.0000	0.000	48656.6	4.689	VV	0.082	9864.61	3.168
5	5.990		0.0000	0.000	34732.2	3.347	VV	0.081	7107.70	2.282
6	6.642		0.0000	0.000	9198.9	0.887	VB	0.066	2313.55	0.743
7	7.242		0.0000	0.000	19028.8	1.834	BB	0.065	4858.36	1.560
8	8.377		0.0000	0.000	2960.2	0.285	BB	0.065	759.02	0.244
9	8.635		0.0000	0.000	1503.8	0.145	BB	0.064	391.71	0.126
10	9.678		0.0000	0.000	20778.2	2.003	BB	0.058	5970.31	1.917
11	9.947		0.0000	0.000	10572.2	1.019	BV	0.049	3562.73	1.144
12	10.066		0.0000	0.000	28882.0	2.784	VV	0.059	8108.99	2.604
13	10.322		0.0000	0.000	17274.1	1.665	VB	0.094	3056.04	0.981
14	11.184		0.0000	0.000	19078.7	1.839	BB	0.056	5655.84	1.816
15	12.032		0.0000	0.000	19064.8	1.837	BV	0.050	6369.08	2.045
16	12.319		0.0000	0.000	7170.1	0.691	VB	0.056	2151.10	0.691
17	12.949		0.0000	0.000	19388.3	1.869	BV	0.050	6511.30	2.091
18	13.172		0.0000	0.000	14251.4	1.374	VB	0.062	3831.86	1.231
19	13.571	Benzene	0.0000	0.000	52545.6	5.064	SBB	0.054	16101.35	5.171
20	13.706		0.0000	0.000	4295.4	0.414	TVB	0.055	1304.06	0.419
21	14.304		0.0000	0.000	25926.7	2.499	BV	0.054	7932.60	2.547
22	14.530		0.0000	0.000	17588.8	1.695	VB	0.051	5714.12	1.835
23	15.311		0.0000	0.000	14802.9	1.427	BB	0.050	4942.90	1.587
24	15.791		0.0000	0.000	11166.7	1.076	BV	0.048	3856.88	1.239
25	15.928		0.0000	0.000	16762.8	1.616	VV	0.052	5386.97	1.730
26	16.191	Toluene	0.0000	0.000	48752.6	4.699	VB	0.051	15782.87	5.068
27	16.785		0.0000	0.000	15493.7	1.493	BB	0.048	5394.03	1.732
28	17.263		0.0000	0.000	16377.7	1.578	BB	0.054	5061.07	1.625
29	17.932		0.0000	0.000	41970.3	4.045	BV	0.050	13985.24	4.491
30	18.340	Ethyl Benzene	0.0000	0.000	46810.5	4.511	VV	0.051	15252.57	4.898
31	18.542	m + p Xylene	0.0000	0.000	45223.5	4.359	VB	0.050	14961.02	4.804
32	18.905		0.0000	0.000	40377.4	3.891	BV	0.049	13714.42	4.404
33	19.017	o xylene + Cl_2C_2	0.0000	0.000	59962.3	5.779	VB	0.057	17397.27	5.587
34	20.080		0.0000	0.000	1209.7	0.117	BV	0.066	305.73	0.098
35	20.479		0.0000	0.000	40807.6	3.933	VV	0.052	13168.13	4.229
36	20.581		0.0000	0.000	44112.9	4.251	VV	0.052	14098.62	4.527
37	21.092		0.0000	0.000	42604.9	4.106	VV	0.051	13975.90	4.488
38	21.249		0.0000	0.000	47233.8	4.552	VV	0.052	15020.32	4.823
39	21.345		0.0000	0.000	29132.1	2.808	VV	0.051	9434.87	3.030
40	21.799		0.0000	0.000	35890.9	3.459	VB	0.052	11581.06	3.719
41	24.429		0.0000	0.000	26579.5	2.562	BV	0.055	8024.07	2.577
42	25.252		0.0000	0.000	17455.0	1.682	VB	0.058	4973.66	1.597

Total Area = 1037589.0, Total Amount = 0.0, Total Height = 311406.0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15
20
25
30
10.49
10.76
12.57
12.97
13.35
13.96
14.50
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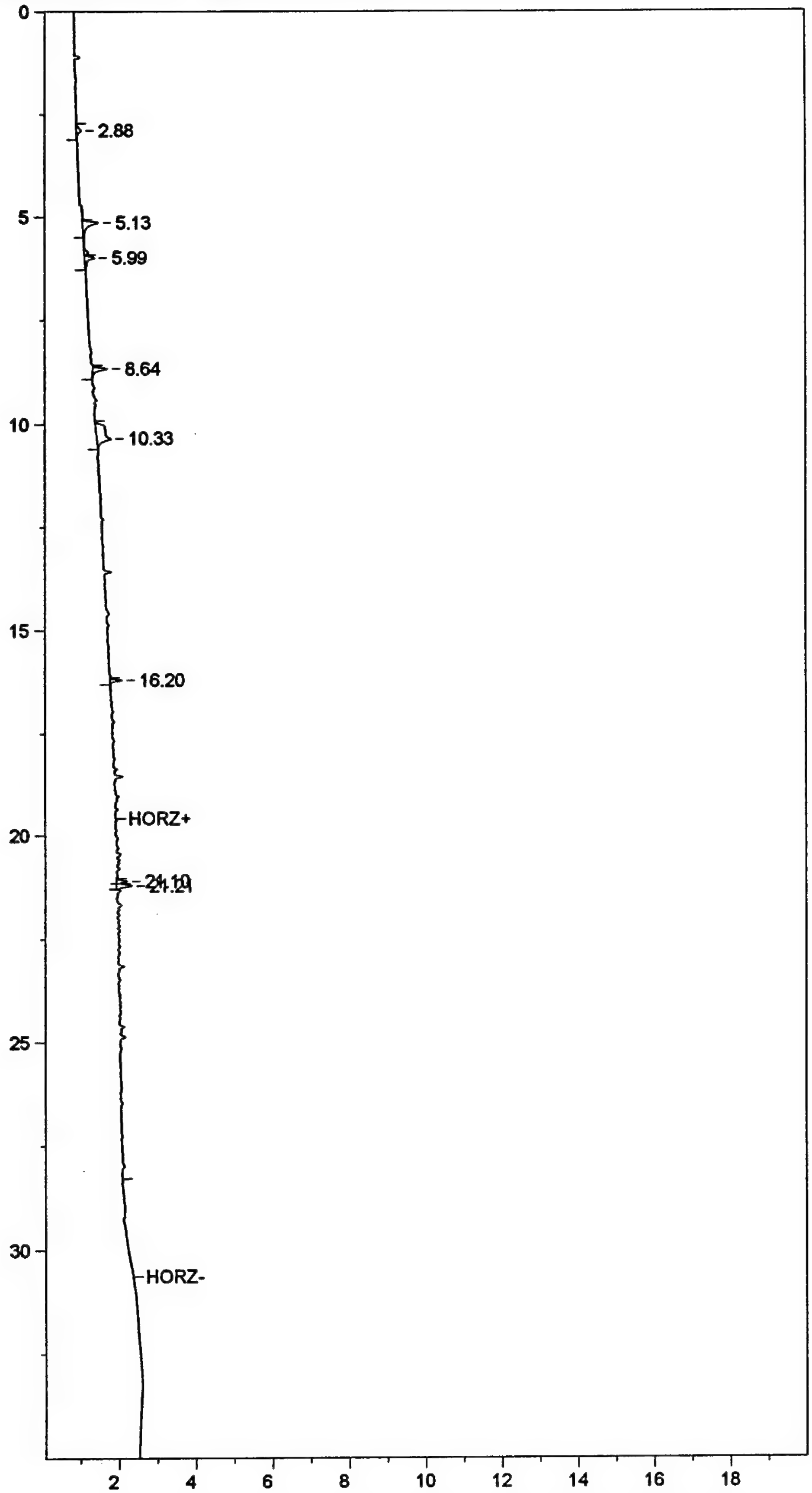
14.93
15.08
15.38
15.62
16.15
16.40
16.74
16.91
17.11
17.42
17.61
17.85
18.24
18.63
18.98
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-18 CYLN. AIR 300CC**
Acquired from HP5890--FID via Port 3 on 11-1-1996 17:45:16
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.03R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	10.488		0.0000	0.000	1261.5	1.210	BV	0.047	444.81	1.708
2	10.755		0.0000	0.000	1867.2	1.792	VB	0.064	489.28	1.879
3	12.575		0.0000	0.000	1785.9	1.714	BB	0.058	515.46	1.980
4	12.971		0.0000	0.000	2865.9	2.750	BB	0.058	823.24	3.162
5	13.347		0.0000	0.000	837.6	0.804	BB	0.055	254.49	0.977
6	13.958		0.0000	0.000	915.3	0.878	BB	0.057	267.72	1.028
7	14.500		0.0000	0.000	4774.6	4.581	BV	0.050	1597.50	6.135
8	14.720		0.0000	0.000	7278.3	6.984	VV	0.060	2036.85	7.823
9	14.933		0.0000	0.000	8965.5	8.603	VV	0.072	2082.18	7.997
10	15.080		0.0000	0.000	7159.9	6.870	VB	0.081	1467.82	5.637
11	15.384		0.0000	0.000	20881.9	20.037	BB	0.095	3664.88	14.075
12	15.620		0.0000	0.000	2049.7	1.967	BB	0.057	596.34	2.290
13	16.153		0.0000	0.000	25492.4	24.461	BB	0.062	6890.92	26.465
14	16.396		0.0000	0.000	1048.1	1.006	BB	0.050	348.34	1.338
15	16.743		0.0000	0.000	1295.0	1.243	BB	0.067	320.13	1.229
16	16.905		0.0000	0.000	4258.0	4.086	BV	0.048	1472.51	5.655
17	17.112		0.0000	0.000	2011.0	1.930	VB	0.084	398.67	1.531
18	17.420		0.0000	0.000	2139.7	2.053	BB	0.072	493.49	1.895
19	17.610		0.0000	0.000	1067.3	1.024	BV	0.070	254.46	0.977
20	17.849		0.0000	0.000	2150.2	2.063	VB	0.083	432.57	1.661
21	18.245		0.0000	0.000	1955.2	1.876	BB	0.066	490.85	1.885
22	18.629		0.0000	0.000	1472.3	1.413	BB	0.053	462.39	1.776
23	18.979		0.0000	0.000	683.1	0.656	BB	0.049	232.58	0.893

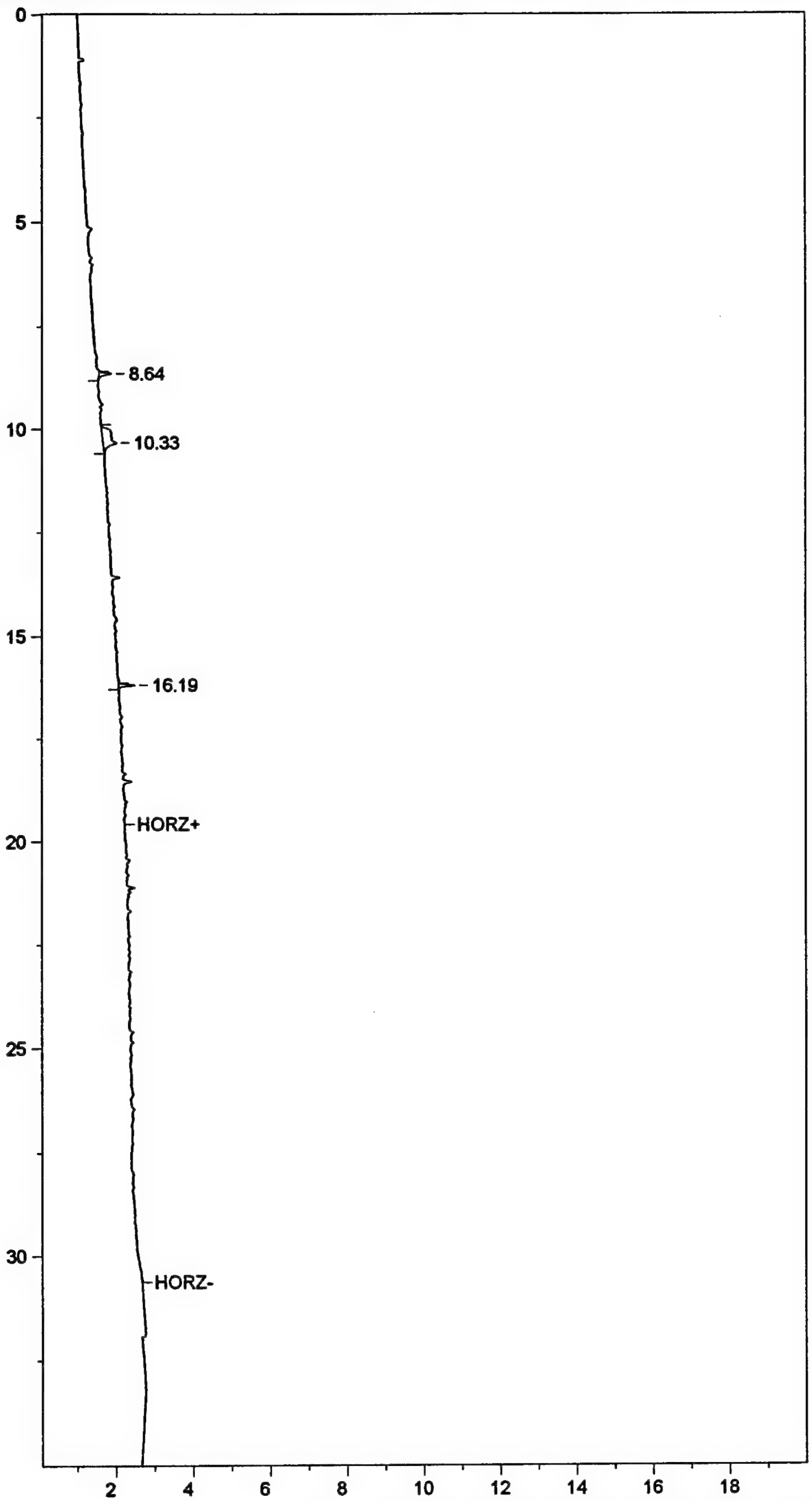
Total Area = 104215.7, Total Amount = 0.0, Total Height = 26037.49


0
5
10
15
20
25
30
2.88
5.13
5.99
8.64
10.33
16.20
HORZ+
21.10
21.21
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-7 CENTER 1 300CC**
Acquired from HP5890--FID via Port 3 on 11-7-1996 10:48:59
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.12R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	2.878		0.0000	0.000	1007.5	5.553	BB	0.135	124.51	5.021
2	5.131		0.0000	0.000	3016.9	16.627	BV	0.122	413.52	16.675
3	5.994		0.0000	0.000	1790.9	9.871	VB	0.115	259.68	10.471
4	8.645		0.0000	0.000	1791.9	9.876	BB	0.078	381.01	15.364
5	10.328		0.0000	0.000	7160.9	39.466	BB	0.326	366.42	14.776
6	16.196		0.0000	0.000	1064.3	5.866	BB	0.055	322.01	12.985
7	21.100		0.0000	0.000	860.5	4.743	BV	0.056	257.75	10.394
8	21.206		0.0000	0.000	1451.4	7.999	VB	0.068	354.98	14.315

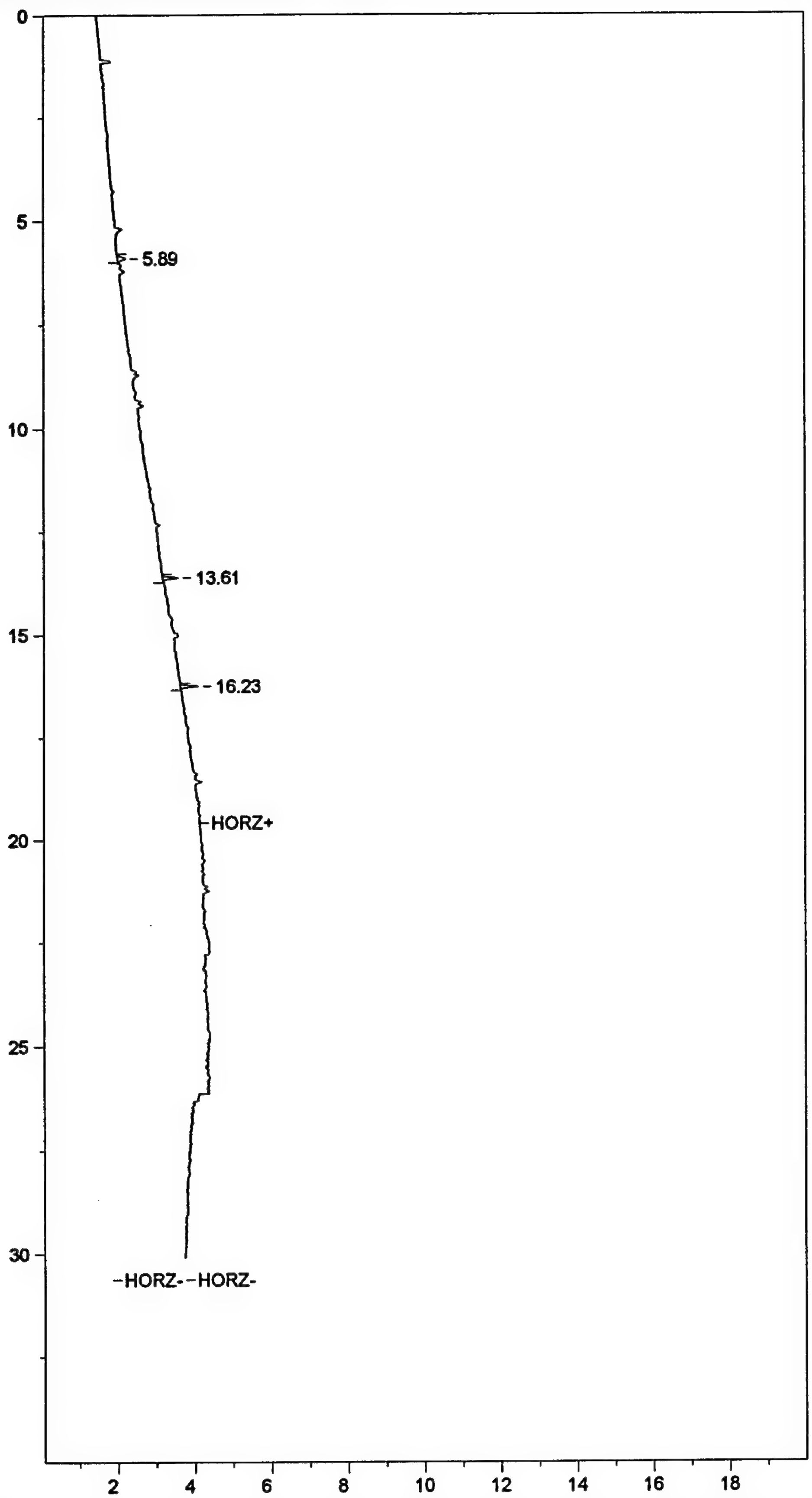
Total Area = 18144.3, Total Amount = 0.0, Total Height = 2479.88


0
5
10
15
20
25
30
8.64
10.33
16.19
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-8 CENTER 2 300CC**
Acquired from HP5890--FID via Port 3 on 11-7-1996 11:41:29
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.13R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	8.639		0.0000	0.000	1409.8	13.877	BB	0.072	324.44	29.210
2	10.329		0.0000	0.000	7365.0	72.496	BB	0.339	362.35	32.623
3	16.193		0.0000	0.000	1384.4	13.627	BB	0.054	423.92	38.167

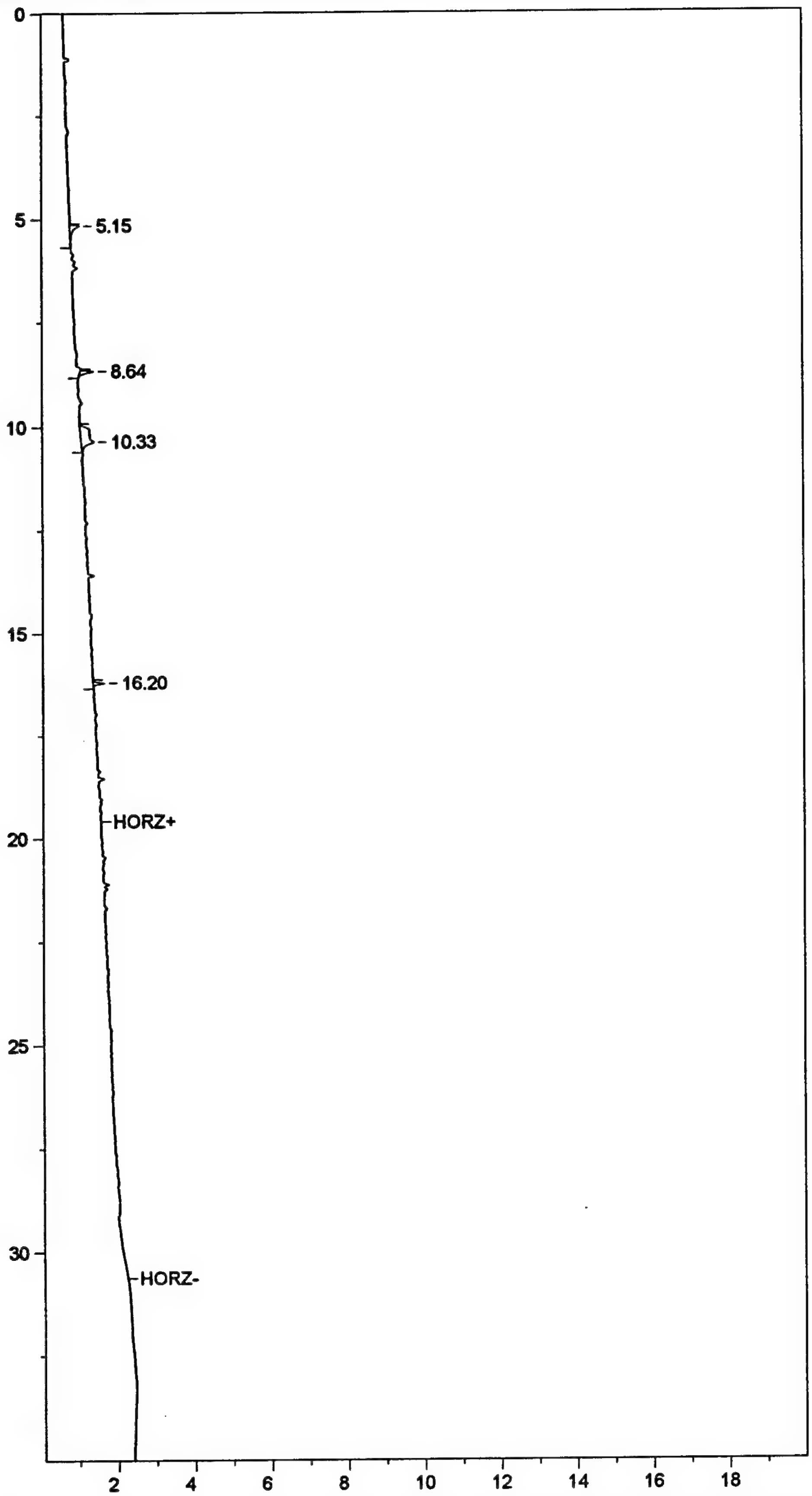
Total Area = 10159.3, Total Amount = 0.0, Total Height = 1110.71


0
5
10
15
20
25
30
-5.89
-13.61
-16.23
-HORZ+
-HORZ--HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-20 PMETER 1 300CC**
Acquired from HP5890--FID via Port 3 on 11-6-1996 17:58:12
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.10R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	5.890		0.0000	0.000	1096.7	27.489	BB	0.087	209.05	19.224
2	13.606		0.0000	0.000	1397.4	35.025	BB	0.057	409.34	37.642
3	16.227		0.0000	0.000	1495.6	37.486	BB	0.053	469.06	43.134

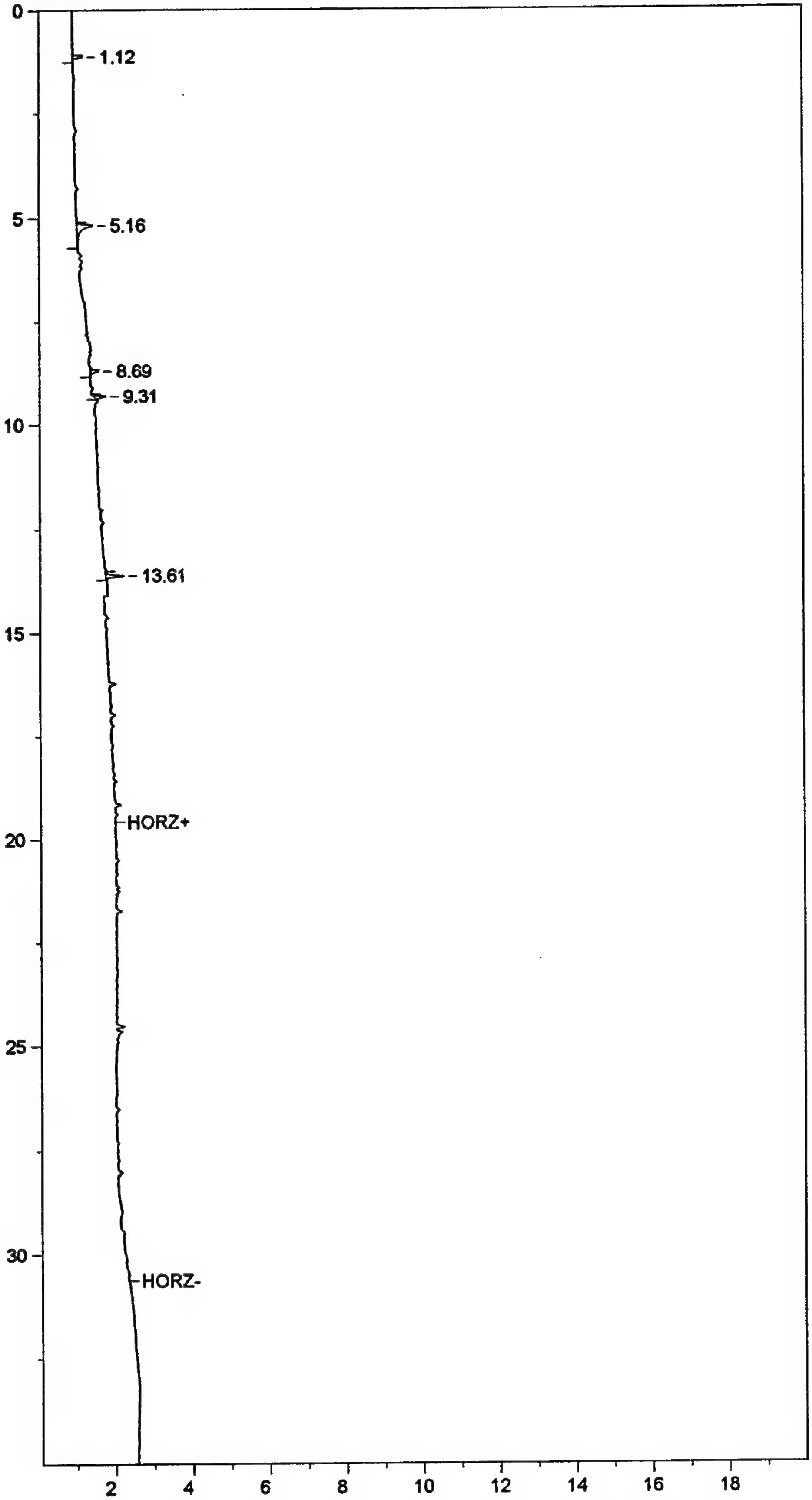
Total Area = 3989.7, Total Amount = 0.0, Total Height = 1087.45


0
5
10
15
20
25
30
5.15
8.64
10.33
16.20
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-21 PMETER 2 300CC**
Acquired from HP5890--FID via Port 3 on 11-7-1996 09:39:07
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.11R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	5.153		0.0000	0.000	2029.7	17.647	BB	0.134	252.17	20.547
2	8.645		0.0000	0.000	1432.8	12.457	BB	0.068	349.09	28.444
3	10.334		0.0000	0.000	7033.9	61.155	BB	0.354	330.96	26.966
4	16.198		0.0000	0.000	1005.3	8.740	BB	0.057	295.08	24.043

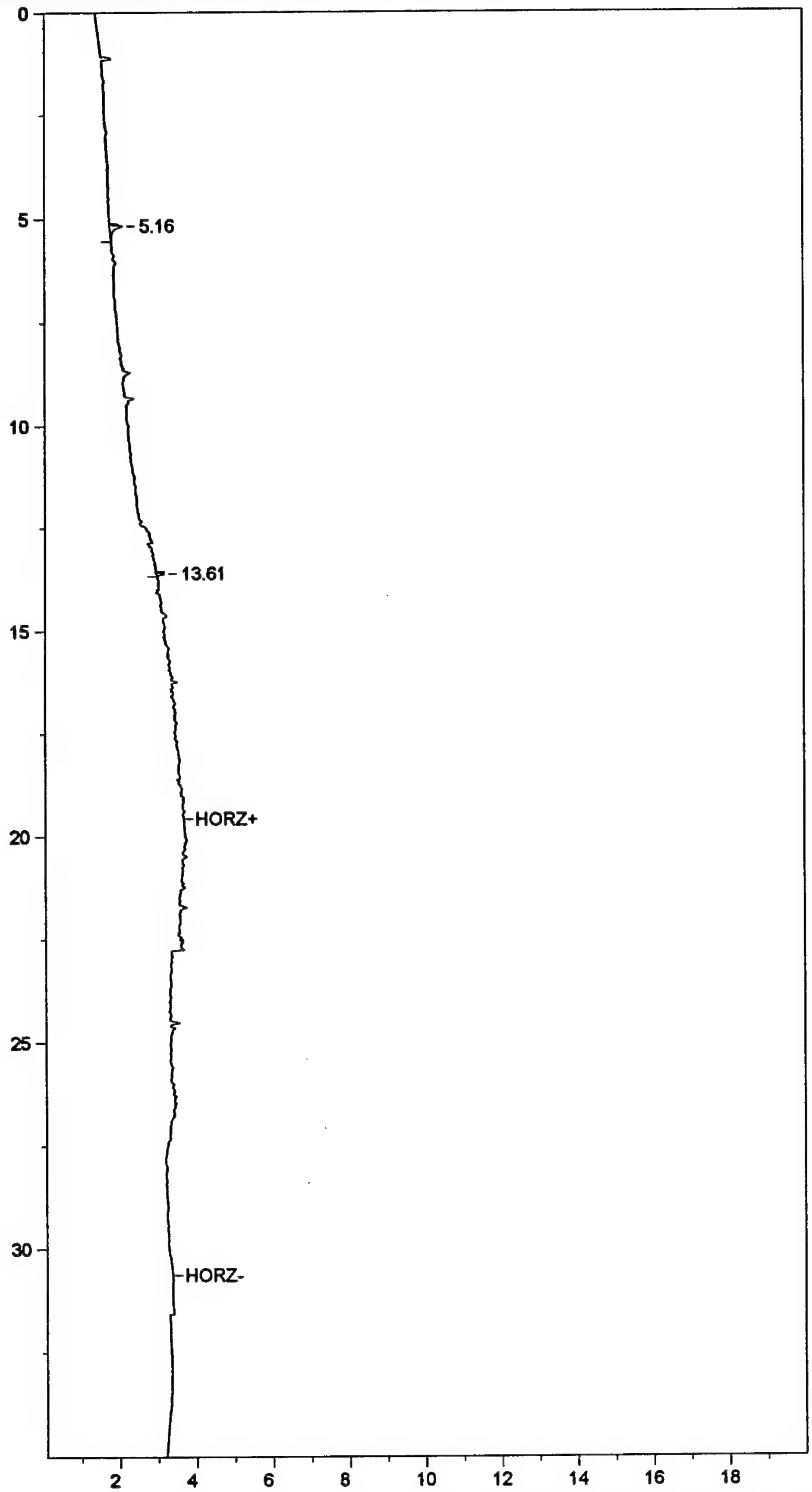
Total Area = 11501.7, Total Amount = 0.0, Total Height = 1227.29


0
5
10
15
20
25
30
1.12
5.16
8.69
9.31
13.61
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-17 BACKGROUND 2 300CC**
Acquired from HP5890--FID via Port 3 on 11-6-1996 16:05:13
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.08R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	1.123		0.0000	0.000	1191.1	14.270	BB	0.074	268.76	15.734
2	5.158		0.0000	0.000	3341.9	40.040	BB	0.132	423.22	24.776
3	8.690		0.0000	0.000	1002.0	12.005	BB	0.076	218.81	12.809
4	9.305		0.0000	0.000	1200.2	14.380	BB	0.062	322.77	18.896
5	13.608		0.0000	0.000	1611.3	19.305	BB	0.057	474.63	27.785

Total Area = 8346.4, Total Amount = 0.0, Total Height = 1708.18

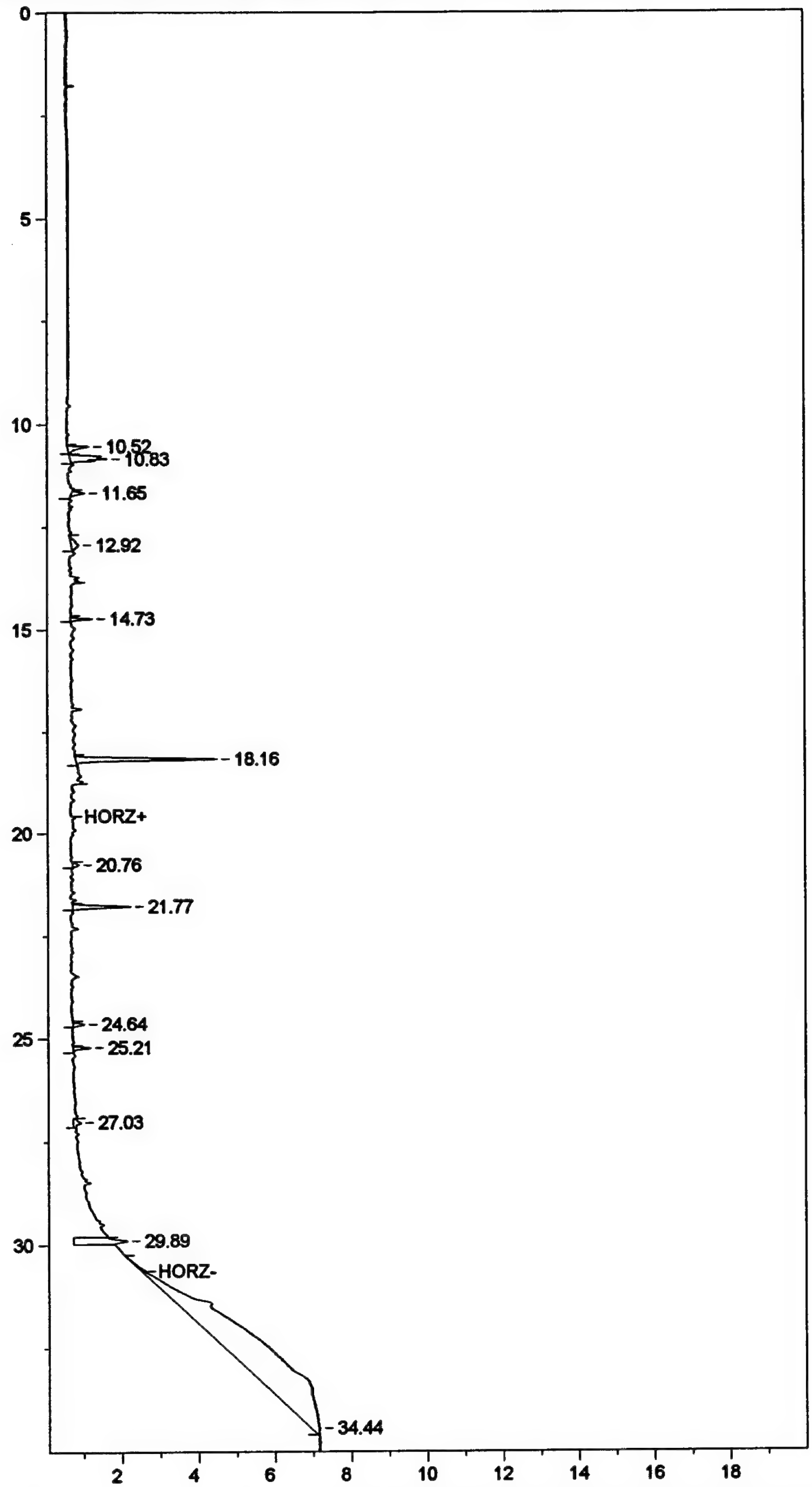


0
5
10
15
20
25
30
5.16
13.61
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-16 BACKGROUND 1 300CC**
Acquired from HP5890--FID via Port 3 on 11-6-1996 16:57:42
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.09R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	5.162		0.0000	0.000	2421.6	78.262	BB	0.121	334.27	62.677
2	13.608		0.0000	0.000	672.6	21.738	BB	0.056	199.05	37.323

Total Area = 3094.2, Total Amount = 0.0, Total Height = 533.32


0
5
10
15
20
25
30
10.52
10.83
11.65
12.92
14.73
18.16
HORZ+
20.76
21.77
24.64
25.21
27.03
29.89
HORZ-
34.44
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-12 CENTER 3 300CC**
Acquired from HP5890--FID via Port 3 on 11-2-1996 12:44:27
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.06R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

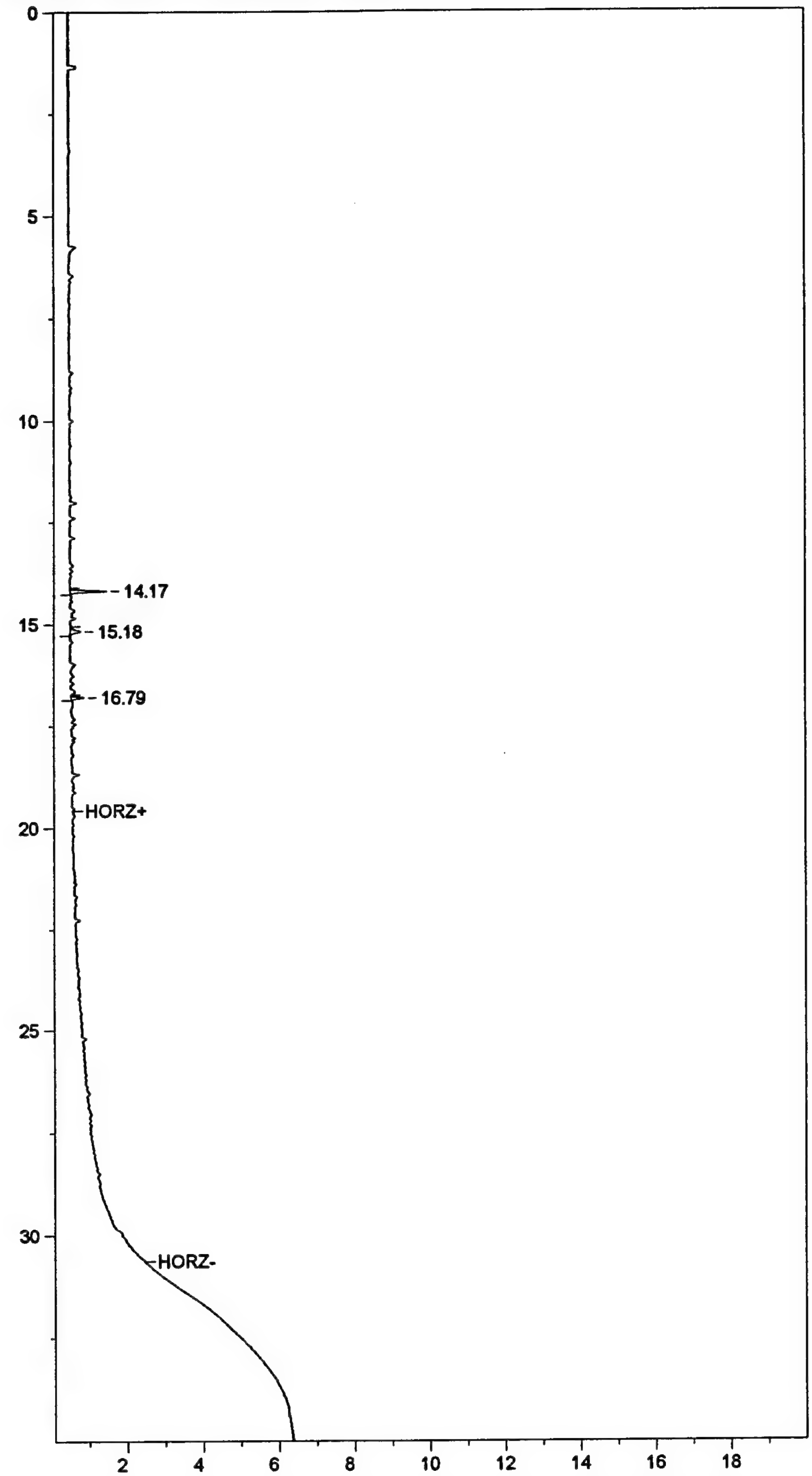
PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	10.525		0.0000	0.000	2646.6	1.109	BV	0.078	567.49	5.921
2	10.827		0.0000	0.000	6730.2	2.821	VB	0.116	970.16	10.122
3	11.654		0.0000	0.000	1505.8	0.631	BB	0.073	345.69	3.607
4	12.918		0.0000	0.000	2180.3	0.914	BB	0.188	192.87	2.012
5	14.730		0.0000	0.000	1707.4	0.716	BB	0.050	573.94	5.988
6	18.165		0.0000	0.000	16409.7	6.879	BB	0.074	3698.02	38.581
7	20.758		0.0000	0.000	731.6	0.307	BB	0.074	164.05	1.712
8	21.770		0.0000	0.000	6357.3	2.665	BB	0.070	1513.33	15.788
9	24.636		0.0000	0.000	1186.3	0.497	BB	0.067	293.98	3.067
10	25.211		0.0000	0.000	1564.6	0.656	BB	0.057	459.56	4.795
11	27.028		0.0000	0.000	701.9	0.294	BB	0.078	149.54	1.560
12	29.893		0.0000	0.000	1747.6	0.733	BB	0.070	415.28	4.333
13	34.444		0.0000	0.000	195085.4	81.778	BB	13.482	241.17	2.516

→ Baseline drift

Total Area = 238554.9, Total Amount = 0.0, Total Height = 9585.08

− 195085.4

43,469.5


0
5
10
15
20
25
30
14.17
15.18
16.79
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-23 CENTER 4 300CC**
Acquired from HP5890--FID via Port 3 on 11-2-1996 15:28:50
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.07R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

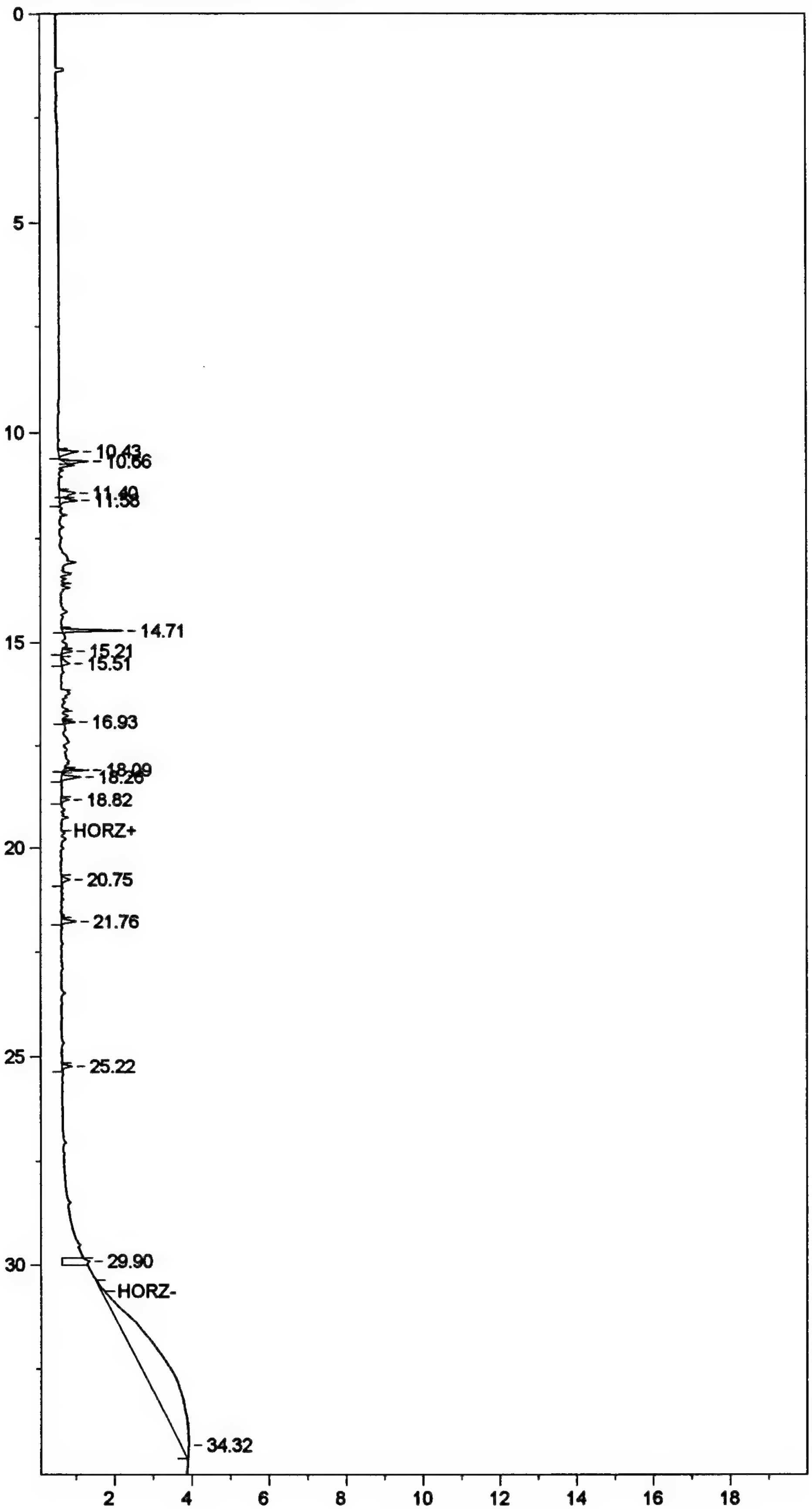
PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	14.169		0.0000	0.000	3068.6	54.870	BB	0.053	973.30	61.163
2	15.176		0.0000	0.000	1430.8	25.583	BB	0.085	281.90	17.715
3	16.790		0.0000	0.000	1093.2	19.547	BB	0.054	336.12	21.122

Total Area = 5592.6, Total Amount = 0.0, Total Height = 1591.32

Blower on

ube	A-20 Perimeter 1	A-21 Perimeter 2	A-7 Center 1	A-8 Center 2
zene	1397.4 (.72)	ND	ND	ND
Tol	1495.6 ~~ND~~ (0.72)	1005.3 (0.48)	1064.3 (0.49 ~~0.51~~)	1384.4 (0.66)
EB	ND	ND	ND	ND
mp	ND	ND	ND	ND
O	ND	ND	ND	ND
otal	3989.7 (2.05)	11501.7 (5.9)	18,144.3 (9.3)	10159.3 (5.2)

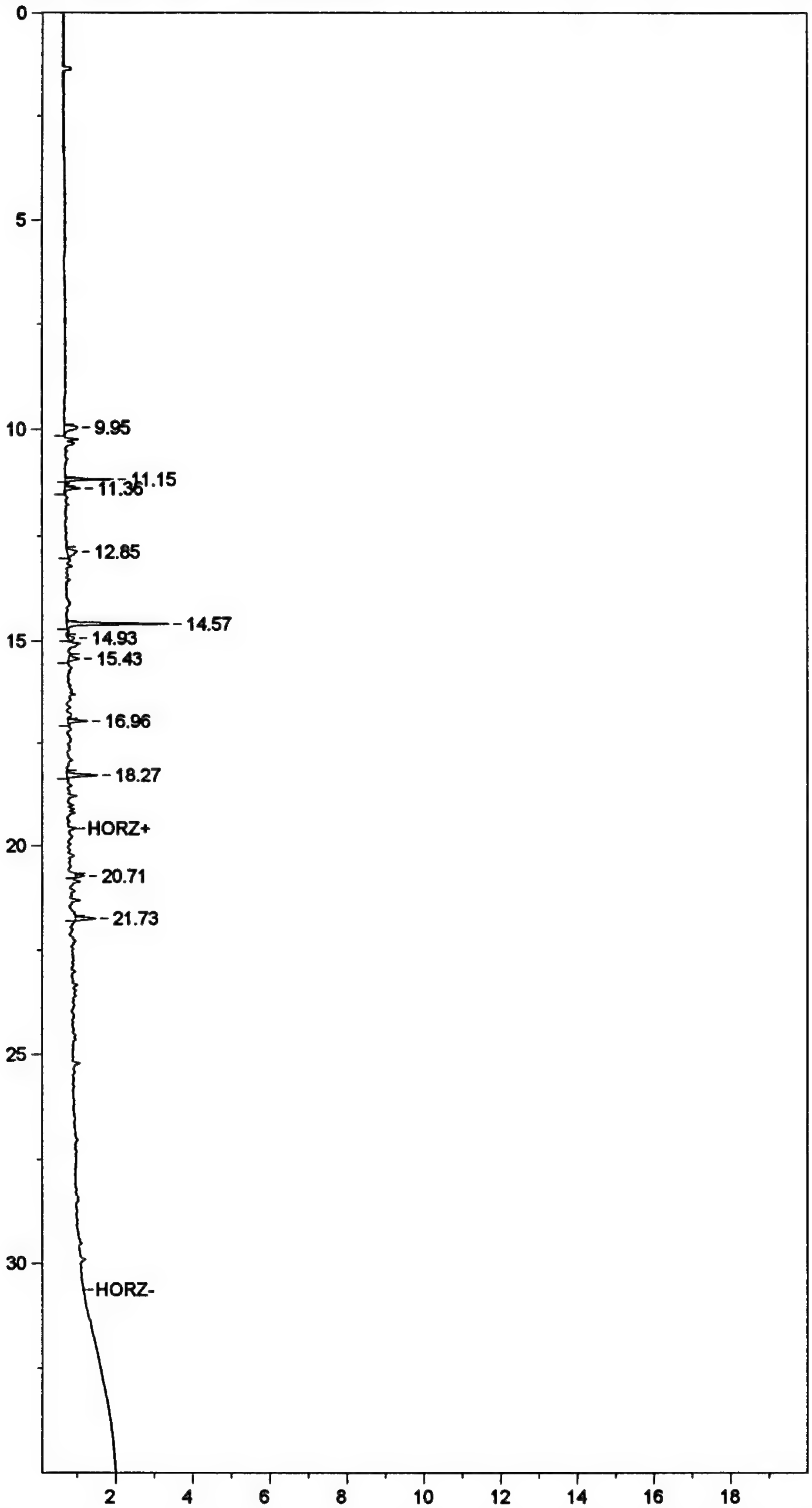
Tube	A-18 Cylinder Air	
Benzene	ND	
Tol	25492.4	(12.24)
EBen	ND	
mp	ND	
O	ND	
Total	104215.7	53.55


0
5
10
15
20
25
30
10.43
10.66
11.40
11.58
14.71
15.21
15.51
16.93
18.09
18.26
18.82
HORZ+
20.75
21.76
25.22
29.90
HORZ-
34.32
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-3 PMETER 3 300CC**
Acquired from HP5890--FID via Port 3 on 11-2-1996 09:40:29
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: C:\CPWIN\DATA1\RHEIN116.04R
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	10.430		0.0000	0.000	2559.8	1.769	BB	0.081	525.22	7.477
2	10.661		0.0000	0.000	1861.5	1.287	BB	0.047	659.17	9.384
3	11.400		0.0000	0.000	2775.7	1.919	BV	0.110	418.81	5.962
4	11.583		0.0000	0.000	2071.7	1.432	VB	0.075	460.06	6.550
5	14.706		0.0000	0.000	4526.7	3.129	BB	0.048	1571.17	22.368
6	15.206		0.0000	0.000	1146.0	0.792	BB	0.071	268.18	3.818
7	15.508		0.0000	0.000	1287.5	0.890	BB	0.100	214.72	3.057
8	16.925		0.0000	0.000	876.7	0.606	BB	0.047	311.51	4.435
9	18.086		0.0000	0.000	1140.8	0.789	BB	0.029	661.64	9.419
10	18.255		0.0000	0.000	2249.0	1.554	BB	0.075	496.76	7.072
11	18.818		0.0000	0.000	900.6	0.623	BB	0.072	208.94	2.975
12	20.753		0.0000	0.000	1380.4	0.954	BV	0.100	230.80	3.286
13	21.762		0.0000	0.000	1786.0	1.234	VB	0.077	389.03	5.538
14	25.217		0.0000	0.000	1058.4	0.732	BB	0.065	270.19	3.846
15	29.900		0.0000	0.000	493.0	0.341	BB	0.067	122.72	1.747
16	34.324		0.0000	0.000	118562.4	81.950	BB	9.178	215.31	3.065

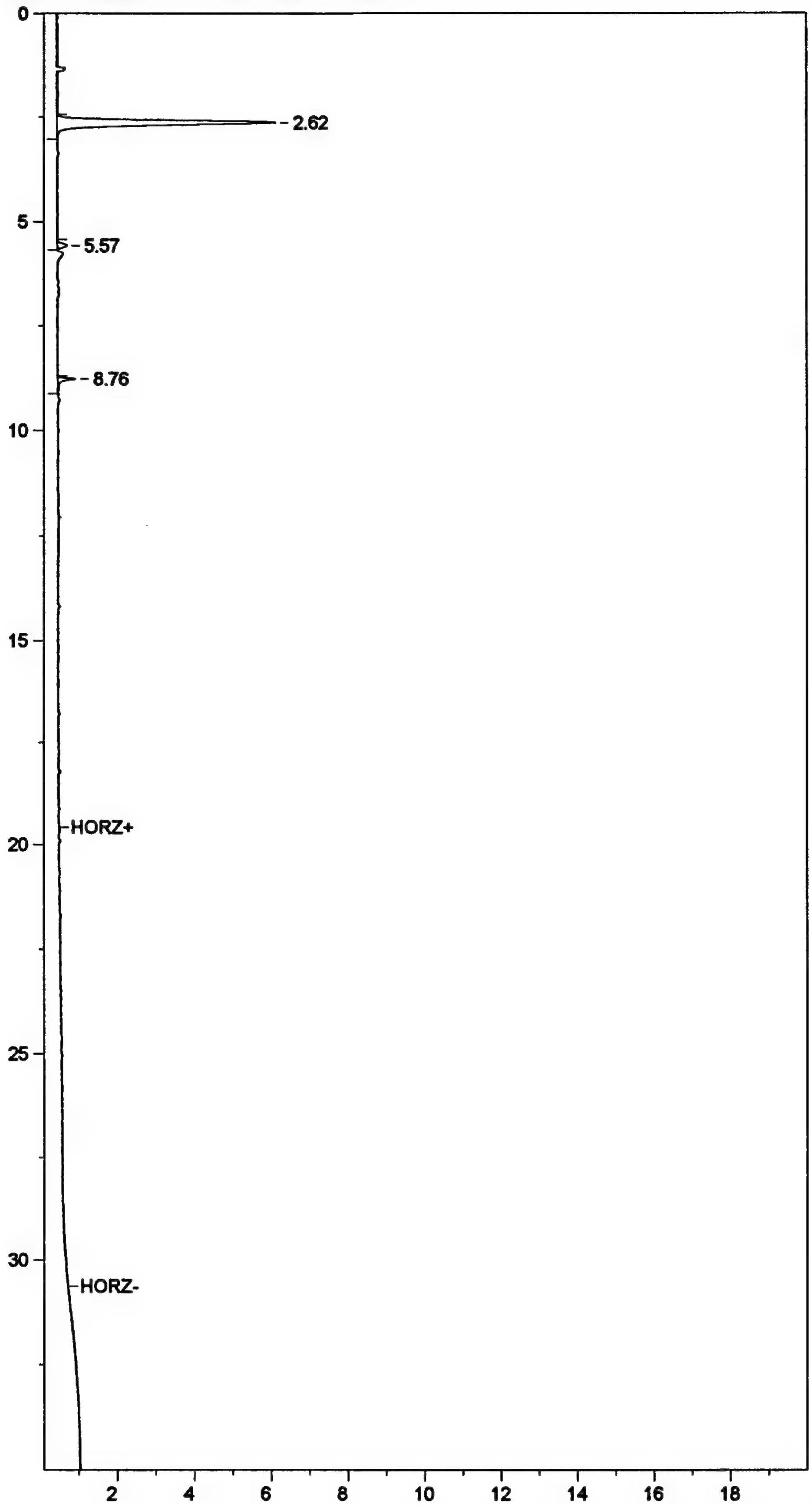
Total Area = 144676.3, Total Amount = 0.0, Total Height = 7024.22


0
5
10
15
20
25
30
9.95
11.15
11.36
12.85
14.57
14.93
15.43
16.96
18.27
HORZ+
20.71
21.73
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-9 PMETER 4 300CC**
Acquired from HP5890--FID via Port 3 on 11-2-1996 10:56:03
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.05R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	9.949		0.0000	0.000	2235.4	8.155	BB	0.110	338.41	4.542
2	11.150		0.0000	0.000	2959.0	10.795	BV	0.039	1255.49	16.851
3	11.363		0.0000	0.000	1422.4	5.189	VB	0.059	405.22	5.439
4	12.851		0.0000	0.000	1932.6	7.051	BB	0.122	263.30	3.534
5	14.573		0.0000	0.000	8331.0	30.395	BB	0.053	2639.65	35.429
6	14.931		0.0000	0.000	1004.7	3.666	BB	0.094	177.53	2.383
7	15.433		0.0000	0.000	1457.3	5.317	BB	0.087	280.35	3.763
8	16.960		0.0000	0.000	1789.3	6.528	BB	0.058	514.84	6.910
9	18.272		0.0000	0.000	3466.7	12.648	BB	0.072	807.38	10.837
10	20.710		0.0000	0.000	747.6	2.727	BB	0.053	235.89	3.166
11	21.733		0.0000	0.000	2063.5	7.529	BB	0.065	532.39	7.146

Total Area = 27409.5, Total Amount = 0.0, Total Height = 7450.45



0
5
10
15
20
25
30
2.62
5.57
8.76
HORZ+
HORZ-
2
4
6
8
10
12
14
16
18

Sample Name: **GR.S.E TUBE A-28 TRIP BLK 300CC**
Acquired from HP5890--FID via Port 3 on 11-1-1996 16:33:55
HP5890 FID RANGE 3
RHEIN-MAIN AB,POL YARD
Data File: **C:\CPWIN\DATA1\RHEIN116.02R**
Method File: C:\CPWIN\DATA1\BTEX2.MET
Calibration file: C:\CPWIN\DATA1\BTEX20A.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	2.621		0.0000	0.000	46181.6	92.270	BB	0.135	5697.36	88.500
2	5.566		0.0000	0.000	1670.2	3.337	BB	0.109	255.00	3.961
3	8.760		0.0000	0.000	2198.9	4.393	BB	0.076	485.32	7.539

Total Area = 50050.7, Total Amount = 0.0, Total Height = 6437.68

Compound	RT (min)	Conc (ppbv)	Area	RF
Benzene	13.57	27.0	52,545.6	0.00051
Toluene	16.19	23.4	48,752.6	0.00048
E Benzene	18.34	23.0	46,810.5	0.00049
m+p Xylene	18.54	20.8	45,223.5	0.00046
O Xylene	19.02	23.6	(.8)(59962.3) 47,969.8	0.00049

Tube A-28	Trip blank	Tube A-3 Perimeter 3	Tube A-9 Perimeter 4
Benzene	ND	ND	ND
Tol	ND	ND	ND
EB	ND	ND	ND
mp	ND	ND	ND
O	ND	ND	ND
Total	50050.7 (25.7 ppbv)	144676.3 (74.3)	27409.5 (14.1)

	Tube A-12 Center 3	Tube A-23 Center 4	A-17 Background #	A16 Backgd 2
Benz	ND	ND	1611.3 (0.83)	672.6 (0.3
Tol	ND	ND	ND	ND
EB	ND	ND	ND	ND
mp	ND	ND	ND	ND
O	ND	ND	ND	ND
Total	43,469.5 ~~238554.9~~	5592.6	8346.4	3094.2
	(~~122.6~~) 22.33	(2.9)	(4.3)	(1.6)

SURFACE EMISSIONS RESULTS

AUGUST 1998

SAMPLE CONCENTRATIONS (August 1998)

Tube ID	Site ID	benzene ppbv	toluene ppbv	ethylbenzene ppbv	m/p-xylene ppbv	o-xylene ppbv	TPH as hexane ppbv
A-5	center BL on	0.59	2.36	n.d.	n.d.	0.54	62.98
A-5	center BL on	0.73	2.49	n.d.	n.d.	n.d.	59.29
A-2	center BL on	c	c	c	c	c	c
A-11	perimeter BL on	n.d.	0.33	n.d.	n.d.	n.d.	7.24
A-11	perimeter BL on	0.46	n.d.	n.d.	n.d.	n.d.	8.37
A-7	perimeter BL on	c	c	c	c	c	c
A-15	center BL off	0.74	1.48	n.d.	n.d.	n.d.	26.13
A-20	center BL off	c	c	c	c	c	c
A-21	perimeter BL off	0.82	13.82	n.d.	0.39	n.d.	258.94
A-24	perimeter BL off	c	c	c	c	c	c
A-25	background	0.55	12.99	n.d.	0.39	n.d.	280.04
A-26	background	c	c	c	c	c	c
A-27	ambient air	0.64	8.26	n.d.	n.d.	n.d.	217.73
A-28	trip blank (loose fittings)	0.42	10.57	n.d.	n.d.	n.d.	141.36

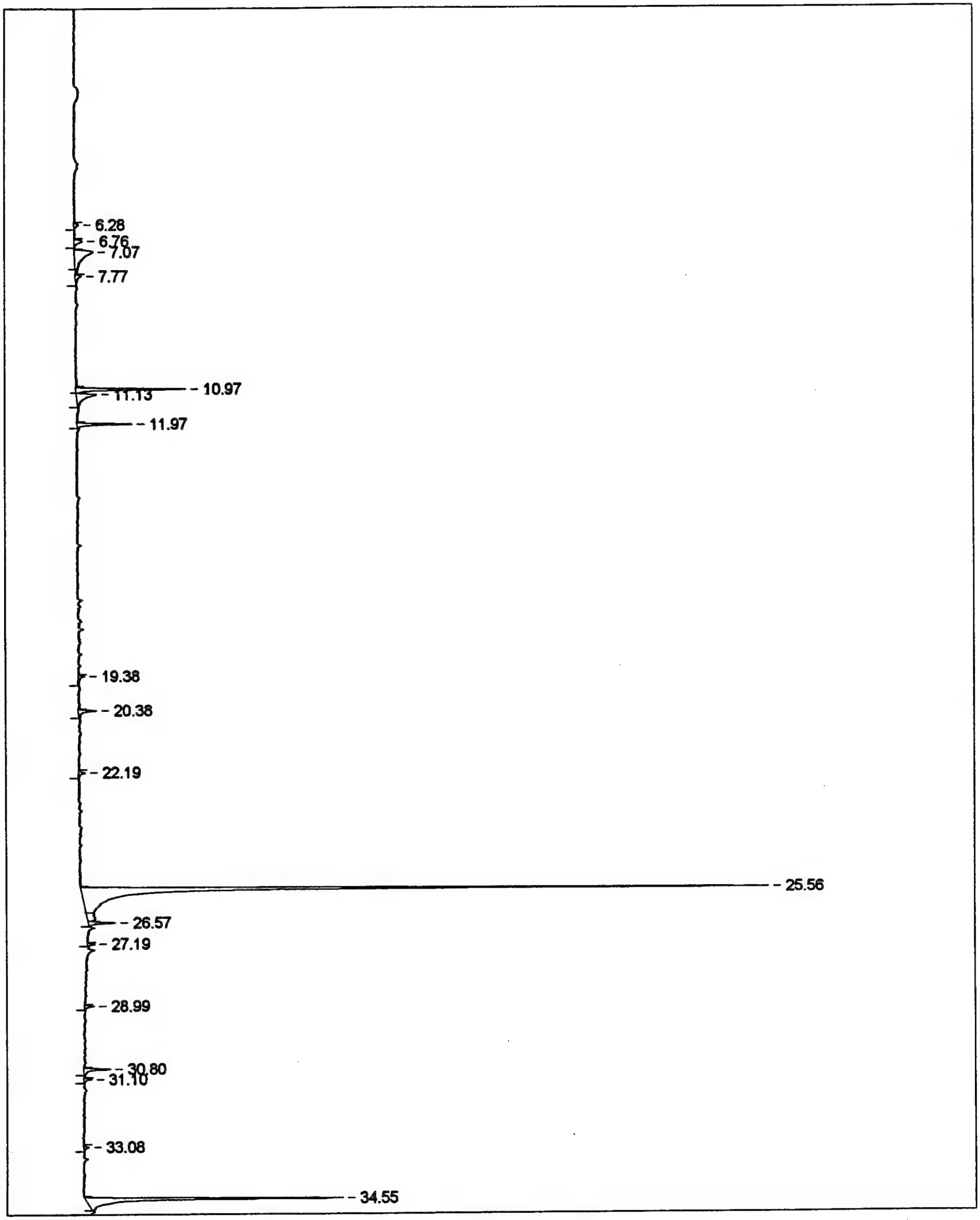
"c" indicates a contaminated sample
Detection level is 0.2 ppbv

FLUX RATES: ug/0.0453m2/minute(August 1998)

Tube ID	Site ID	benzene	toluene	ethylbenzene	m/p-xylene	o-xylene	TPH as hexane
A-5	center BL on	0.00380	0.01776	n.d.	n.d.	0.00469	0.45223
A-5	center BL on	0.00470	0.01874	n.d.	n.d.	n.d.	0.42577
A-2	center BL on	c	c	c	c	c	c
A-11	perimeter BL on	n.d.	0.00252	n.d.	n.d.	n.d.	0.05196
A-11	perimeter BL on	0.00293	n.d.	n.d.	n.d.	n.d.	0.06014
A-7	perimeter BL on	c	c	c	c	c	c
A-15	center BL off	0.00473	0.01111	n.d.	n.d.	n.d.	0.18763
A-20	center BL off	c	c	c	c	c	c
A-21	perimeter BL off	0.00525	0.10393	n.d.	0.00341	n.d.	1.85942
A-24	perimeter BL off	c	c	c	c	c	c
A-25	background	0.00353	0.09769	n.d.	0.00338	n.d.	2.01096
A-26	background	c	c	c	c	c	c
A-27	ambient air	0.00413	0.06214	n.d.	n.d.	n.d.	1.56355
A-28	trip blank (loose fittings)	0.00268	0.07947	n.d.	n.d.	n.d.	1.01510

A-5 CENTER BLO ON 360CC

——— C:\CPWIN\DATA1\RE090998.08R



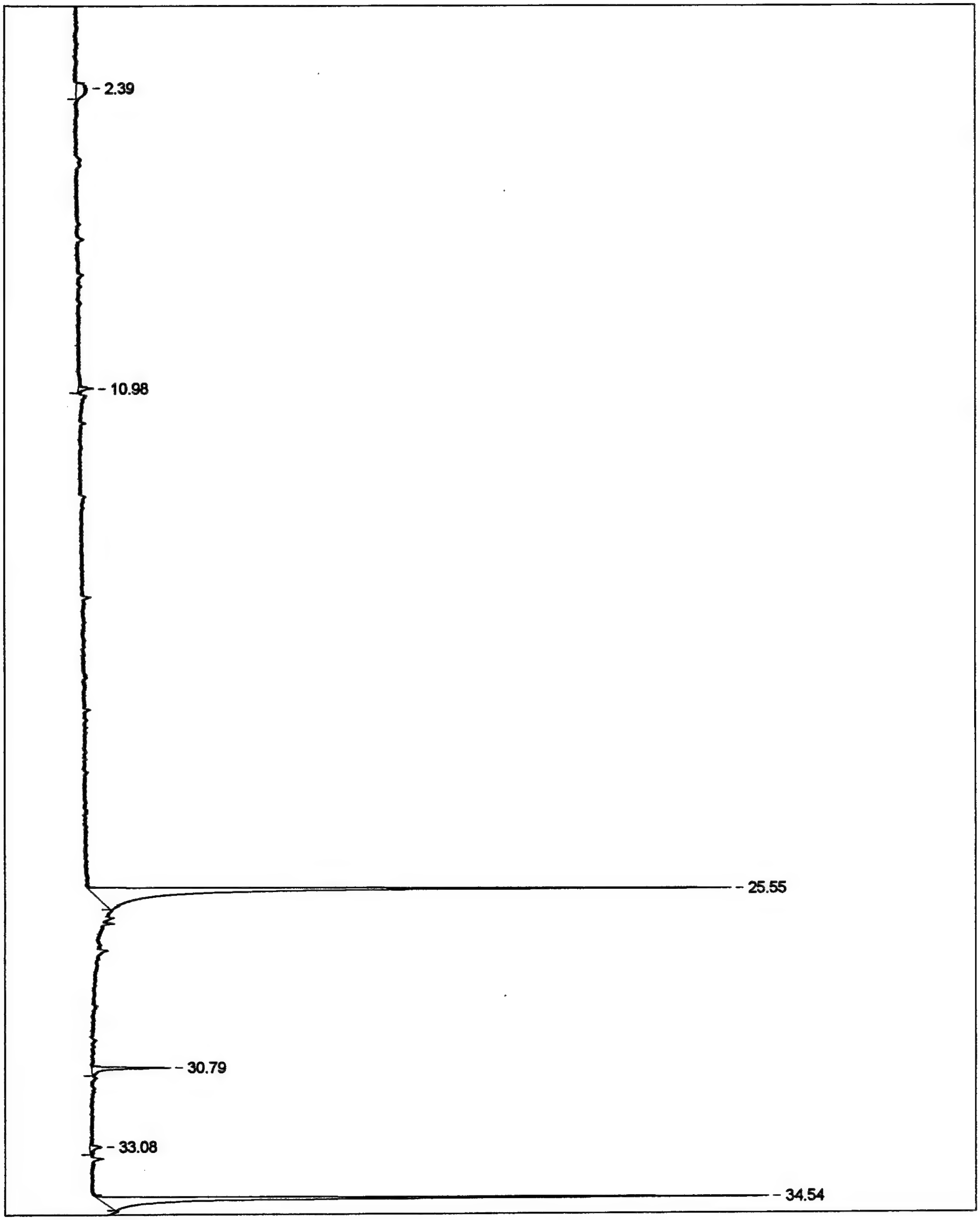
Sample Name: **A-5 CENTER BLO ON 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/10/98 05:22:17pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\RE090998.08R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	6.280		0.0000	0.000	730.1	0.000	BB	0.096	126.79	0.000
2	6.763		0.0000	0.000	1392.7	0.000	BB	0.110	211.55	0.000
3	7.071		0.0000	0.000	7390.8	0.000	BV	0.252	488.87	0.000
4	7.767		0.0000	0.000	1080.9	0.000	VB	0.114	158.43	0.000
5	10.970		0.0000	0.000	9127.2	0.000	BV	0.054	2837.34	0.000
6	11.132		0.0000	0.000	4452.7	0.000	VB	0.140	531.72	0.000
7	11.965		0.0000	0.000	4313.8	0.000	BB	0.050	1427.80	0.000
8	19.380		0.0000	0.000	866.8	0.000	BB	0.088	165.10	0.000
9	20.385		0.0000	0.000	1885.2	0.000	BB	0.065	480.83	0.000
10	22.190		0.0000	0.000	842.8	0.000	BB	0.075	186.83	0.000
11	25.560		0.0000	0.000	86623.2	0.000	BV	0.082	17697.89	0.000
12	26.571		0.0000	0.000	2341.8	0.000	VB	0.055	711.97	0.000
13	27.193		0.0000	0.000	556.1	0.000	BB	0.049	190.98	0.000
14	28.988		0.0000	0.000	863.9	0.000	BB	0.054	264.34	0.000
15	30.801		0.0000	0.000	2769.7	0.000	BV	0.066	701.99	0.000
16	31.100		0.0000	0.000	766.2	0.000	VB	0.056	226.23	0.000
17	33.081		0.0000	0.000	640.9	0.000	BB	0.071	150.56	0.000
18	34.549		0.0000	0.000	27282.6	0.000	BB	0.069	6592.85	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0

A-11 PERIM BLO ON 360CC

——— C:\CPWIN\DATA1\RE090998.09R



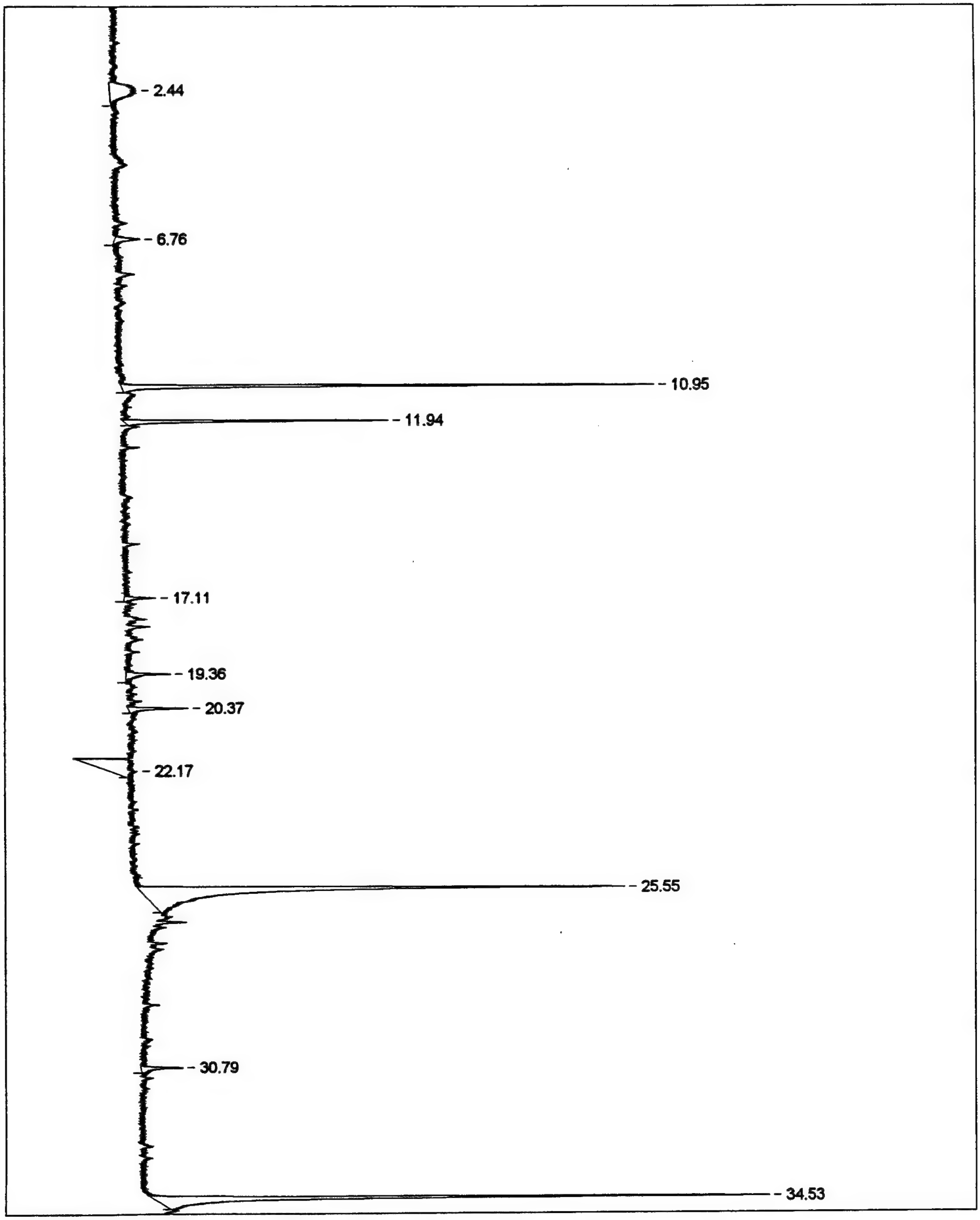
Sample Name: **A-11 PERIM BLO ON 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/10/98 06:20:02pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\RE090998.09R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	2.393		0.0000	0.000	2081.9	0.000	BB	0.294	118.19	0.000
2	10.983		0.0000	0.000	679.7	0.000	BB	0.073	156.26	0.000
3	25.547		0.0000	0.000	38660.1	0.000	BB	0.098	6560.75	0.000
4	30.791		0.0000	0.000	3135.3	0.000	BB	0.065	808.02	0.000
5	33.076		0.0000	0.000	790.3	0.000	BB	0.107	123.27	0.000
6	34.539		0.0000	0.000	28339.6	0.000	BB	0.069	6842.15	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0

A-15 CENTER BLO OFF 360CC

——— C:\CPWIN\DATA1\RE090998.10R



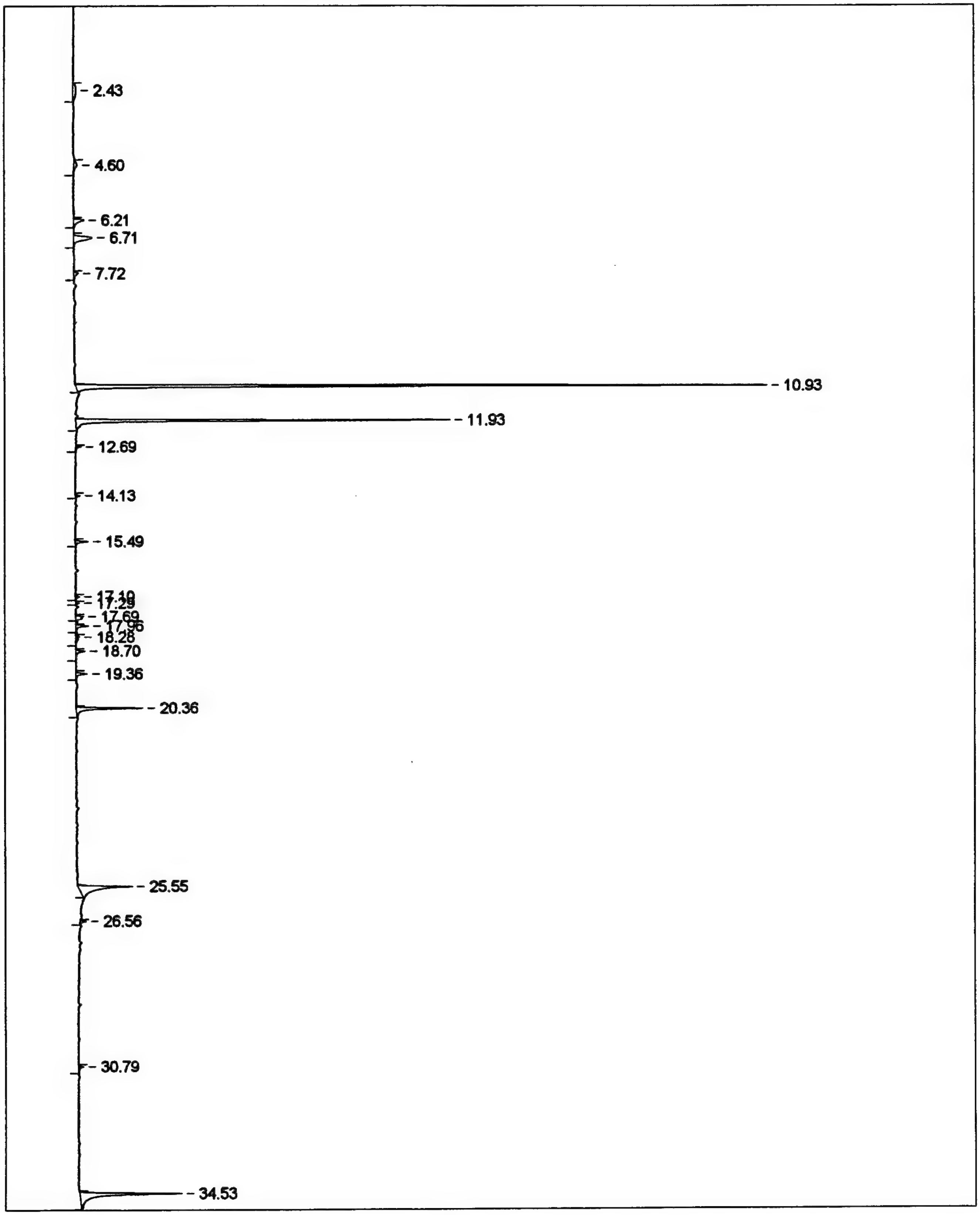
Sample Name: **A-15 CENTER BLO OFF 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/10/98 07:16:50pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\RE090998.10R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: C:\CPWIN\DATA1\42COMP97.CAL

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	2.438		0.0000	0.000	3164.2	5.178	BB	0.365	144.38	1.281
2	6.758		0.0000	0.000	785.0	1.285	BB	0.099	132.20	1.173
3	10.949		0.0000	0.000	9141.1	14.960	BB	0.055	2782.38	24.682
4	11.945		0.0000	0.000	4212.1	6.893	BB	0.051	1376.49	12.211
5	17.110		0.0000	0.000	616.8	1.009	BB	0.063	163.83	1.453
6	19.361		0.0000	0.000	1142.8	1.870	BB	0.083	228.59	2.028
7	20.368		0.0000	0.000	1161.9	1.902	BB	0.062	313.57	2.782
8	22.171		0.0000	0.000	4960.0	8.117	BB	0.563	146.92	1.303
9	25.546		0.0000	0.000	20341.6	33.290	BB	0.133	2544.83	22.575
10	30.793		0.0000	0.000	957.9	1.568	BB	0.073	218.25	1.936
11	34.534		0.0000	0.000	14620.0	23.927	BB	0.076	3221.37	28.576

Total Area = 61103.4, Total Amount = 0.0, Total Height = 11272.81

A-21 PERIM. BLO OFF 360CC

——— C:\CPWIN\DATA1\RE090998.11R



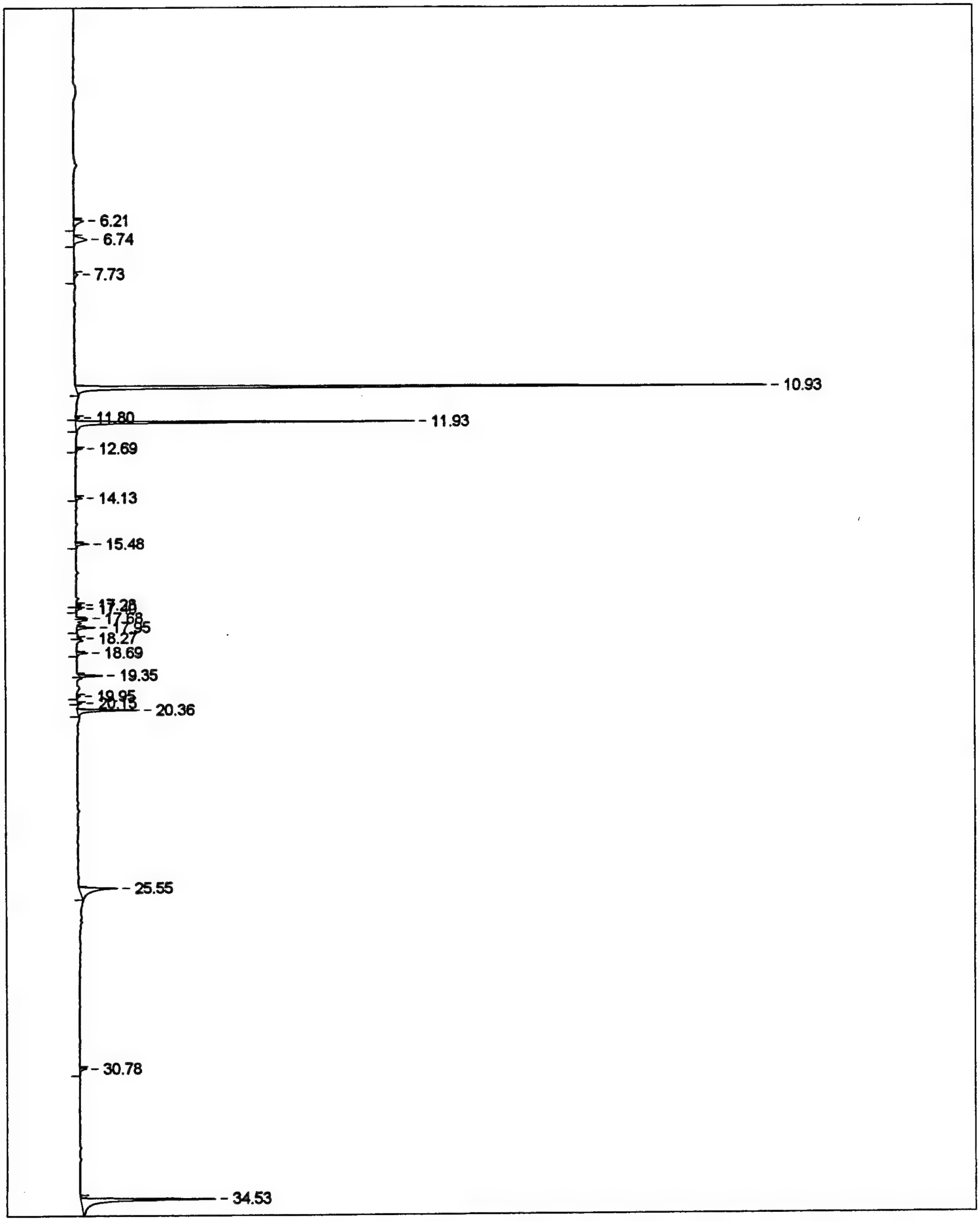
Sample Name: **A-21 PERIM. BLO OFF 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/10/98 08:13:44pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\RE090998.11R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	2.433		0.0000	0.000	2747.4	0.000	BB	0.341	134.23	0.000
2	4.598		0.0000	0.000	1691.1	0.000	BB	0.193	146.37	0.000
3	6.208		0.0000	0.000	2672.9	0.000	BB	0.104	429.65	0.000
4	6.706		0.0000	0.000	5921.0	0.000	BB	0.129	762.78	0.000
5	7.725		0.0000	0.000	1118.6	0.000	BB	0.099	189.03	0.000
6	10.929		0.0000	0.000	86226.5	0.000	BB	0.052	27849.49	0.000
7	11.928		0.0000	0.000	43813.5	0.000	BB	0.048	15084.54	0.000
8	12.690		0.0000	0.000	854.2	0.000	BB	0.062	229.84	0.000
9	14.128		0.0000	0.000	684.5	0.000	BB	0.058	196.70	0.000
10	15.488		0.0000	0.000	1696.6	0.000	BB	0.054	528.00	0.000
11	17.103		0.0000	0.000	604.8	0.000	BB	0.062	163.85	0.000
12	17.293		0.0000	0.000	484.6	0.000	BB	0.053	151.33	0.000
13	17.687		0.0000	0.000	1709.7	0.000	BV	0.088	323.57	0.000
14	17.957		0.0000	0.000	1809.8	0.000	VV	0.059	512.73	0.000
15	18.281		0.0000	0.000	1107.3	0.000	VV	0.126	146.98	0.000
16	18.697		0.0000	0.000	1507.3	0.000	VB	0.067	374.87	0.000
17	19.356		0.0000	0.000	1673.9	0.000	BB	0.060	466.88	0.000
18	20.356		0.0000	0.000	8999.0	0.000	BB	0.056	2685.93	0.000
19	25.547		0.0000	0.000	13379.1	0.000	BB	0.103	2174.68	0.000
20	26.558		0.0000	0.000	841.5	0.000	BB	0.055	254.88	0.000
21	30.787		0.0000	0.000	953.1	0.000	BB	0.076	207.86	0.000
22	34.532		0.0000	0.000	19050.1	0.000	BB	0.078	4090.27	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0

A-25 BACKGROUND 360CC

C:\CPWIN\DATA1\RE090998.12R



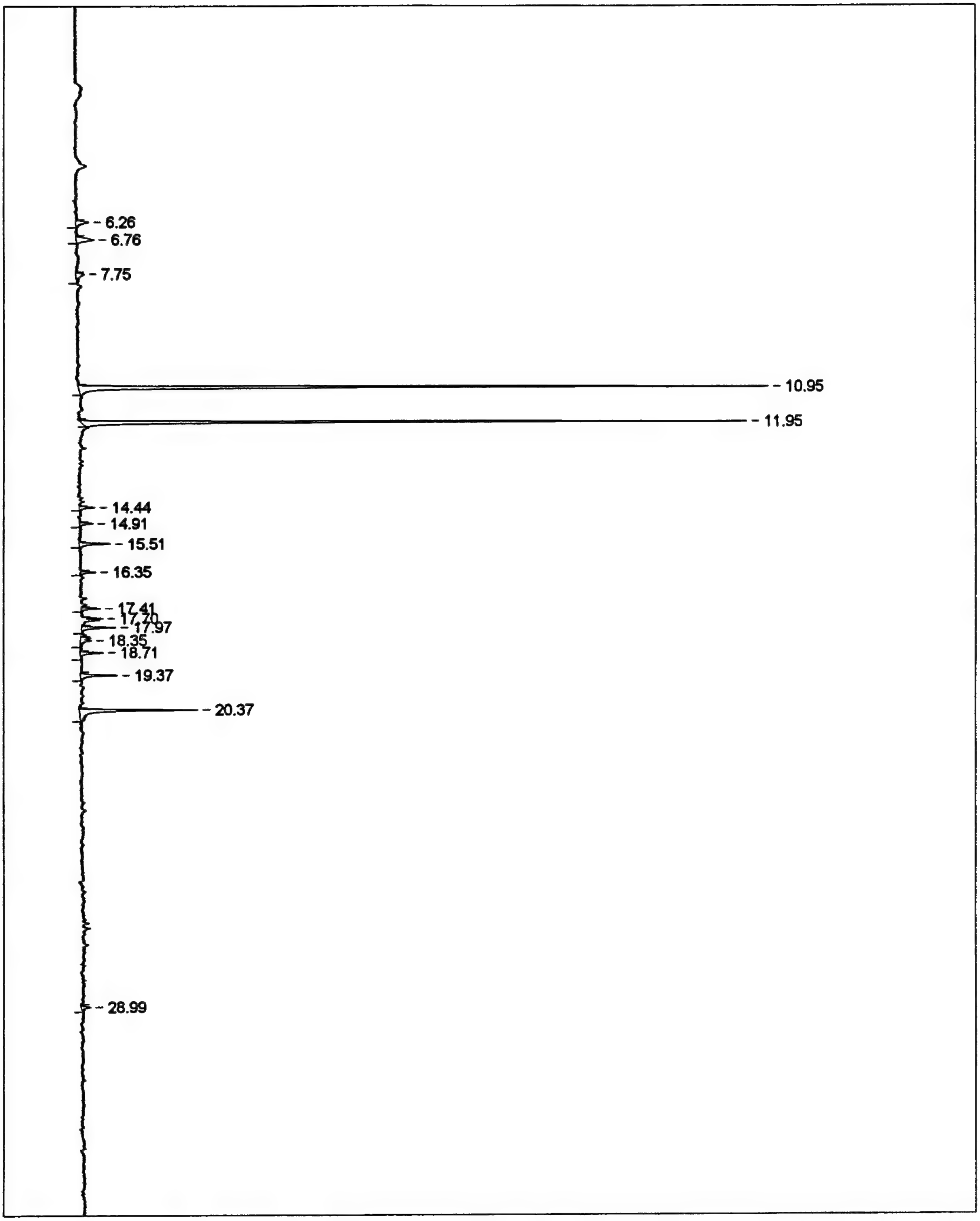
Sample Name: **A-25 BACKGROUND 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/10/98 09:11:38pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\RE090998.12R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	6.205		0.0000	0.000	2945.8	0.000	BB	0.111	443.75	0.000
2	6.742		0.0000	0.000	4564.0	0.000	BB	0.125	606.77	0.000
3	7.733		0.0000	0.000	1221.4	0.000	BB	0.109	185.94	0.000
4	10.929		0.0000	0.000	95528.1	0.000	BB	0.051	31270.25	0.000
5	11.800		0.0000	0.000	543.3	0.000	BB	0.050	182.59	0.000
6	11.926		0.0000	0.000	44044.0	0.000	BB	0.048	15337.87	0.000
7	12.687		0.0000	0.000	980.2	0.000	BB	0.053	307.80	0.000
8	14.125		0.0000	0.000	935.6	0.000	BB	0.053	295.88	0.000
9	15.484		0.0000	0.000	1872.4	0.000	BB	0.051	606.56	0.000
10	17.283		0.0000	0.000	768.7	0.000	BV	0.051	250.89	0.000
11	17.397		0.0000	0.000	841.8	0.000	VB	0.052	268.08	0.000
12	17.683		0.0000	0.000	623.5	0.000	BB	0.031	330.84	0.000
13	17.954		0.0000	0.000	2572.3	0.000	BB	0.050	851.86	0.000
14	18.268		0.0000	0.000	408.1	0.000	BB	0.040	171.33	0.000
15	18.695		0.0000	0.000	1551.4	0.000	BB	0.051	508.59	0.000
16	19.351		0.0000	0.000	2870.9	0.000	BB	0.044	1090.89	0.000
17	19.945		0.0000	0.000	631.0	0.000	BB	0.062	168.70	0.000
18	20.150		0.0000	0.000	483.9	0.000	BB	0.040	203.29	0.000
19	20.355		0.0000	0.000	8821.6	0.000	BB	0.052	2812.05	0.000
20	25.546		0.0000	0.000	11146.1	0.000	BB	0.104	1780.06	0.000
21	30.783		0.0000	0.000	1373.8	0.000	BB	0.072	319.81	0.000
22	34.529		0.0000	0.000	28426.7	0.000	BB	0.078	6081.91	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0

A-28 TRIP BLANK 360CC

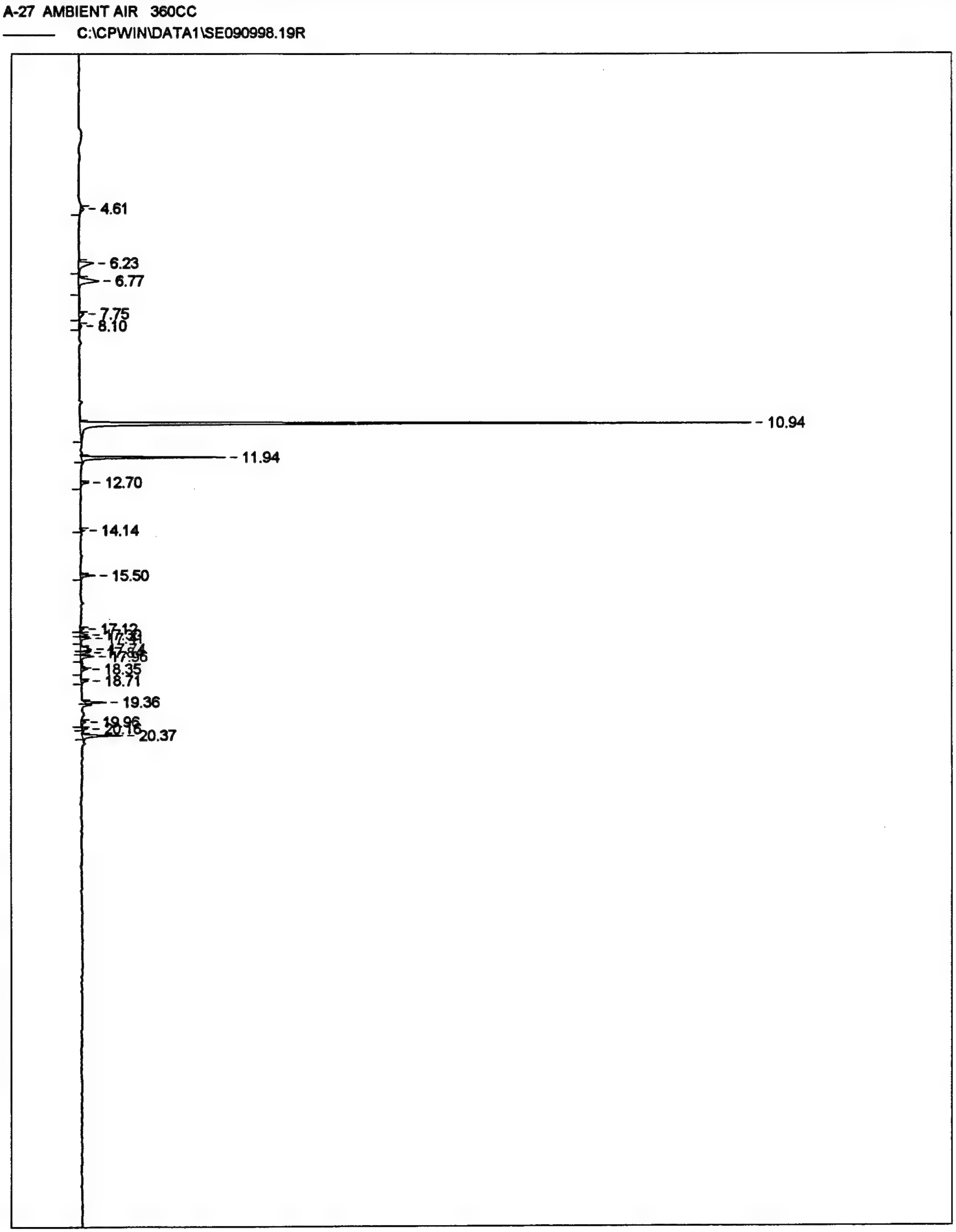
C:\CPWIN\DATA1\SE090998.18R



Sample Name: **A-28 TRIP BLANK 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/16/98 12:10:50pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\SE090998.18R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	6.260		0.0000	0.000	1256.2	0.000	BB	0.096	217.39	0.000
2	6.762		0.0000	0.000	1848.1	0.000	BB	0.106	291.63	0.000
3	7.750		0.0000	0.000	1070.6	0.000	BB	0.119	149.72	0.000
4	10.953		0.0000	0.000	36152.1	0.000	BB	0.053	11473.47	0.000
5	11.949		0.0000	0.000	31669.7	0.000	BB	0.048	11073.94	0.000
6	14.442		0.0000	0.000	818.6	0.000	BB	0.052	261.66	0.000
7	14.910		0.0000	0.000	760.8	0.000	BB	0.055	230.36	0.000
8	15.510		0.0000	0.000	1694.3	0.000	BB	0.054	521.91	0.000
9	16.347		0.0000	0.000	786.6	0.000	BB	0.051	256.17	0.000
10	17.414		0.0000	0.000	959.9	0.000	BB	0.049	325.58	0.000
11	17.705		0.0000	0.000	446.3	0.000	BB	0.034	219.60	0.000
12	17.970		0.0000	0.000	1876.3	0.000	BV	0.054	576.75	0.000
13	18.355		0.0000	0.000	1410.6	0.000	VB	0.123	190.99	0.000
14	18.713		0.0000	0.000	1496.7	0.000	BB	0.064	388.02	0.000
15	19.371		0.0000	0.000	2182.1	0.000	BB	0.059	618.89	0.000
16	20.373		0.0000	0.000	7621.1	0.000	BB	0.065	1969.15	0.000
17	28.985		0.0000	0.000	645.4	0.000	BB	0.070	154.43	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0


A-27 AMBIENT AIR 360CC
C:\CPWIN\DATA1\SE090998.19R
4.61
6.23
6.77
7.75
8.10
10.94
11.94
12.70
14.14
15.50
17.12
18.35
18.71
19.36
19.96
20.16
20.37

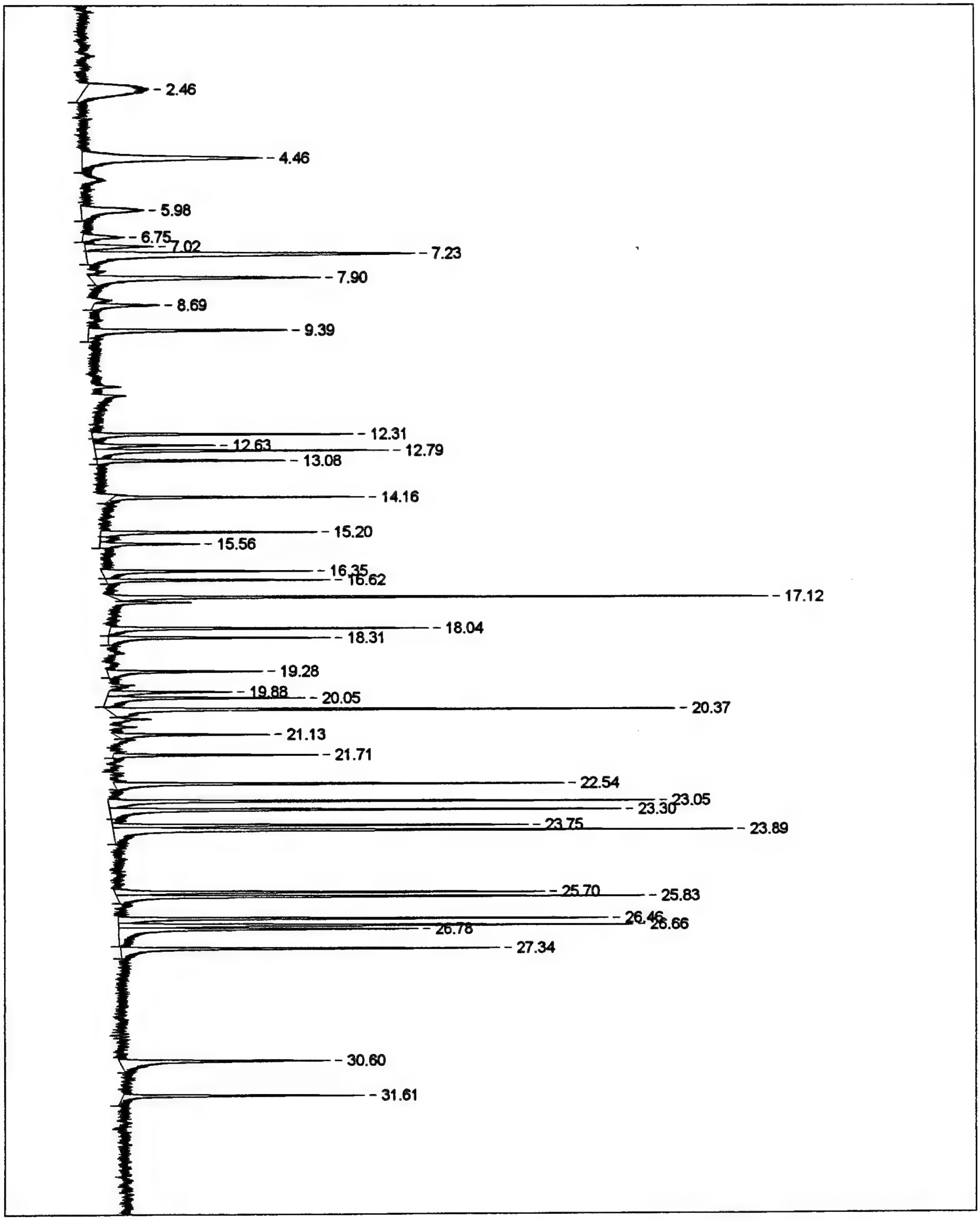
Sample Name: **A-27 AMBIENT AIR 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/16/98 01:07:16pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\SE090998.19R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	4.612		0.0000	0.000	1014.5	0.000	BB	0.109	155.81	0.000
2	6.227		0.0000	0.000	4402.0	0.000	BV	0.118	622.52	0.000
3	6.767		0.0000	0.000	6292.1	0.000	VV	0.125	840.19	0.000
4	7.750		0.0000	0.000	1300.6	0.000	VB	0.104	209.38	0.000
5	8.095		0.0000	0.000	649.4	0.000	BB	0.093	116.99	0.000
6	10.941		0.0000	0.000	89547.2	0.000	BB	0.053	28063.69	0.000
7	11.943		0.0000	0.000	17605.3	0.000	BB	0.049	6041.23	0.000
8	12.696		0.0000	0.000	1239.6	0.000	BB	0.060	343.49	0.000
9	14.143		0.0000	0.000	546.4	0.000	BB	0.048	188.56	0.000
10	15.497		0.0000	0.000	2088.8	0.000	BB	0.055	627.89	0.000
11	17.120		0.0000	0.000	663.6	0.000	BV	0.067	164.11	0.000
12	17.296		0.0000	0.000	1183.5	0.000	VV	0.059	334.23	0.000
13	17.405		0.0000	0.000	1709.5	0.000	VV	0.064	444.56	0.000
14	17.745		0.0000	0.000	2568.6	0.000	VV	0.088	488.12	0.000
15	17.843		0.0000	0.000	1338.7	0.000	VV	0.057	390.13	0.000
16	17.964		0.0000	0.000	2262.2	0.000	VV	0.066	572.11	0.000
17	18.348		0.0000	0.000	1243.0	0.000	VB	0.070	295.40	0.000
18	18.710		0.0000	0.000	1010.6	0.000	BB	0.056	300.20	0.000
19	19.362		0.0000	0.000	2334.7	0.000	BB	0.043	896.13	0.000
20	19.965		0.0000	0.000	971.0	0.000	BB	0.078	208.61	0.000
21	20.162		0.0000	0.000	663.1	0.000	BB	0.043	256.14	0.000
22	20.370		0.0000	0.000	5339.9	0.000	BB	0.053	1679.87	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0

COMP42 SD10941 10-1000 360CC

——— C:\CPWIN\DATA1\RE090998.01R



Sample Name: **COMP42 SD10941 10-1000 360CC**
Acquired from Chrom1--Det1A via port 1 on 9/9/98 03:27:19pm by GWK
header 1 for chan 1
header 2 for chan 1
Data File: **C:\CPWIN\DATA1\RE090998.01R**
Method File: C:\CPWIN\DATA1\42COMP.MET
Calibration File: (none)

PK#	Ret Time	Name	Amount	Amount%	Area	Area%	Type	Width	Height	Height%
1	2.460		0.0000	0.000	3521.6	0.000	BB	0.305	192.41	0.000
2	4.460		0.0000	0.000	5129.4	0.000	BB	0.160	534.56	0.000
3	5.977		0.0000	0.000	2025.2	0.000	BB	0.180	187.93	0.000
4	6.755		0.0000	0.000	765.4	0.000	BB	0.103	124.45	0.000
5	7.020		0.0000	0.000	1112.6	0.000	BV	0.090	205.33	0.000
6	7.228		0.0000	0.000	6702.3	0.000	VB	0.115	974.72	0.000
7	7.903		0.0000	0.000	3723.9	0.000	BB	0.091	682.59	0.000
8	8.690		0.0000	0.000	927.7	0.000	BB	0.078	199.41	0.000
9	9.391		0.0000	0.000	2718.5	0.000	BB	0.077	589.36	0.000
10	12.315		0.0000	0.000	2413.4	0.000	BV	0.052	772.59	0.000
11	12.634		0.0000	0.000	1259.2	0.000	VV	0.058	361.02	0.000
12	12.785		0.0000	0.000	3111.0	0.000	VV	0.060	867.66	0.000
13	13.085		0.0000	0.000	1762.9	0.000	VB	0.053	558.04	0.000
14	14.162		0.0000	0.000	2244.0	0.000	BB	0.051	738.08	0.000
15	15.204		0.0000	0.000	2064.3	0.000	BV	0.054	638.53	0.000
16	15.560		0.0000	0.000	1044.0	0.000	VB	0.059	295.95	0.000
17	16.351		0.0000	0.000	2289.9	0.000	BV	0.061	624.27	0.000
18	16.623		0.0000	0.000	1884.2	0.000	VB	0.048	660.47	0.000
19	17.118		0.0000	0.000	5505.0	0.000	BB	0.047	1944.33	0.000
20	18.037		0.0000	0.000	2966.2	0.000	BB	0.053	941.41	0.000
21	18.310		0.0000	0.000	2145.9	0.000	BB	0.055	654.75	0.000
22	19.283		0.0000	0.000	1687.0	0.000	BB	0.061	458.76	0.000
23	19.878		0.0000	0.000	1376.0	0.000	BV	0.063	364.43	0.000
24	20.052		0.0000	0.000	2372.1	0.000	VB	0.068	584.48	0.000
25	20.375		0.0000	0.000	5579.5	0.000	BB	0.055	1689.32	0.000
26	21.125		0.0000	0.000	1449.4	0.000	BB	0.053	456.98	0.000
27	21.713		0.0000	0.000	1722.5	0.000	BB	0.047	604.97	0.000
28	22.543		0.0000	0.000	4129.1	0.000	BB	0.052	1335.08	0.000
29	23.045		0.0000	0.000	5128.2	0.000	BV	0.053	1622.70	0.000
30	23.296		0.0000	0.000	5154.7	0.000	VV	0.057	1519.84	0.000
31	23.747		0.0000	0.000	3878.9	0.000	VV	0.052	1234.22	0.000
32	23.890		0.0000	0.000	7176.9	0.000	VB	0.065	1837.95	0.000
33	25.699		0.0000	0.000	3947.7	0.000	BV	0.051	1278.99	0.000
34	25.827		0.0000	0.000	4907.9	0.000	VB	0.052	1566.13	0.000
35	26.462		0.0000	0.000	4435.3	0.000	BV	0.051	1453.94	0.000
36	26.660		0.0000	0.000	5219.8	0.000	VV	0.057	1527.59	0.000
37	26.779		0.0000	0.000	3902.6	0.000	VB	0.073	885.46	0.000
38	27.342		0.0000	0.000	3890.9	0.000	BB	0.058	1124.32	0.000
39	30.600		0.0000	0.000	2944.9	0.000	BB	0.079	621.59	0.000
40	31.607		0.0000	0.000	2300.8	0.000	BB	0.054	710.84	0.000

Total Area = 0.0, Total Amount = 0.0, Total Height = 0.0

APPENDIX D

RESULTS FROM SOIL GAS PERMEABILITY TESTING

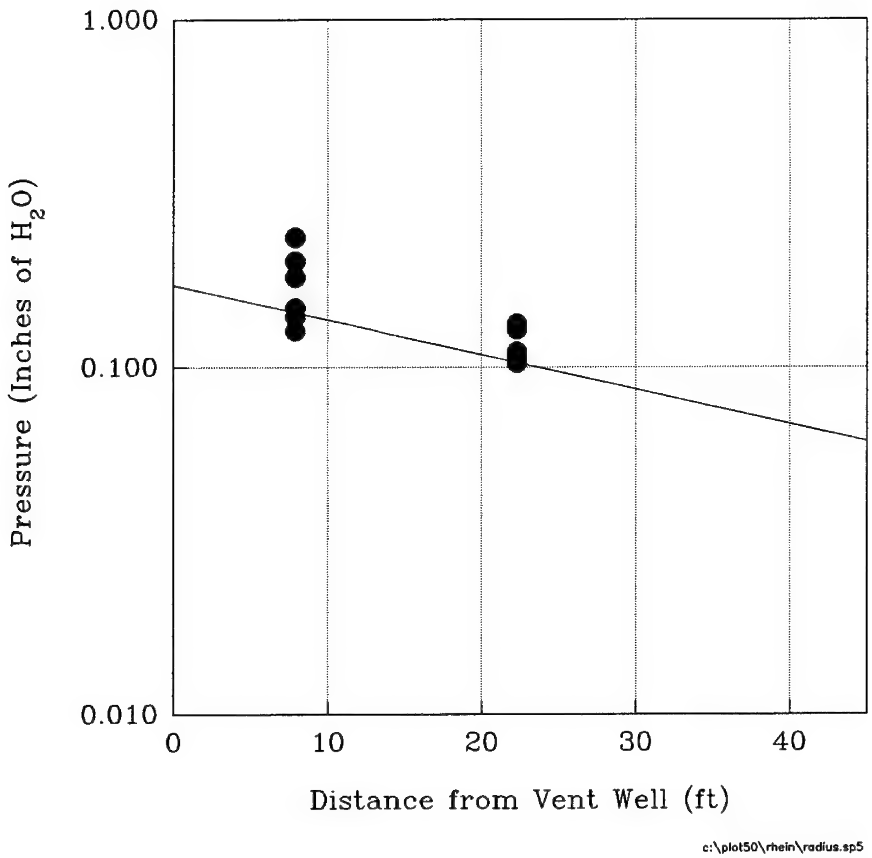


Figure D1. Radius of Influence at the Bioventing Test Plot

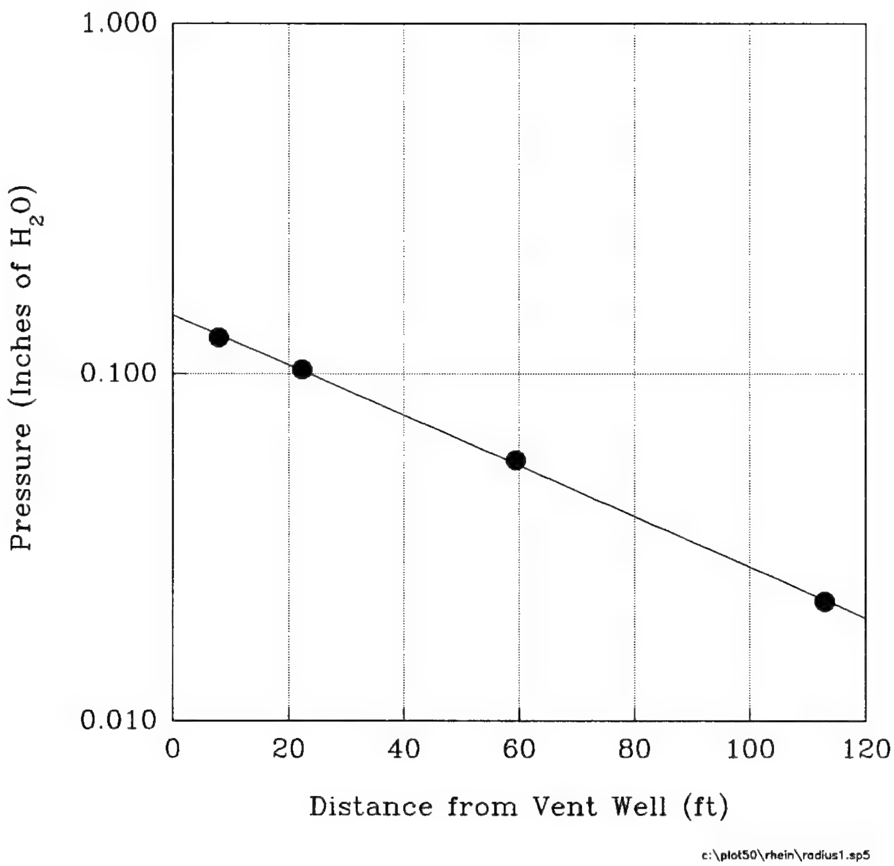


Figure D2. Radius of Influence at a Depth of 1 m at the Bioventing Test Plot

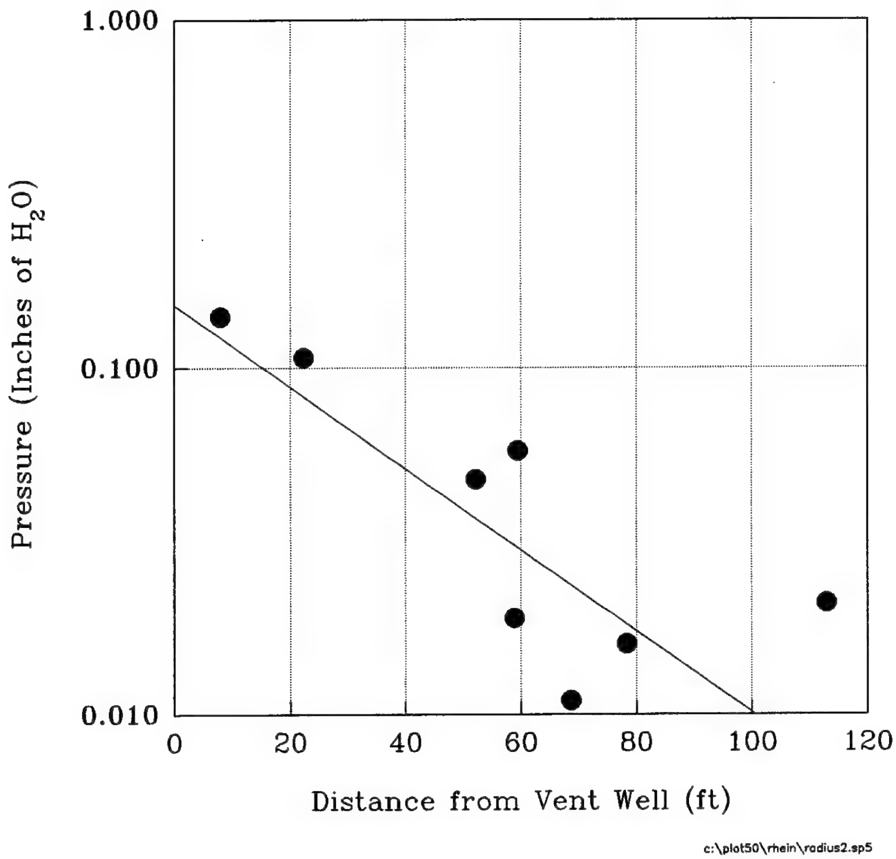


Figure D3. Radius of Influence at a Depth of 2 m at the Bioventing Test Plot

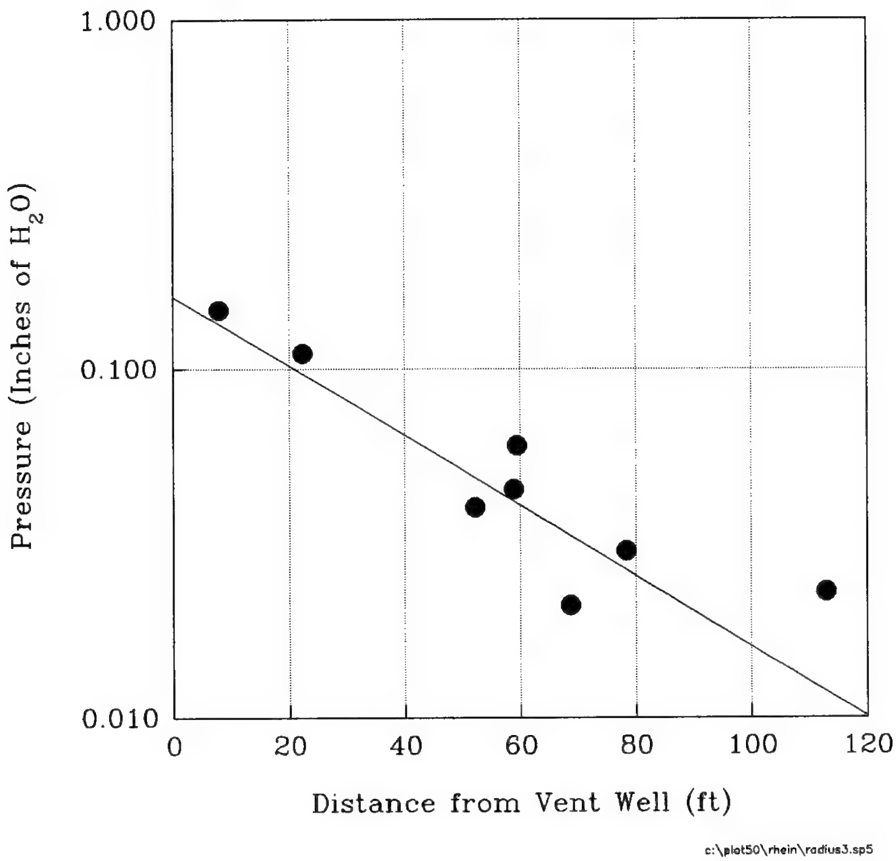


Figure D4. Radius of Influence at a Depth of 3 m at the Bioventing Test Plot

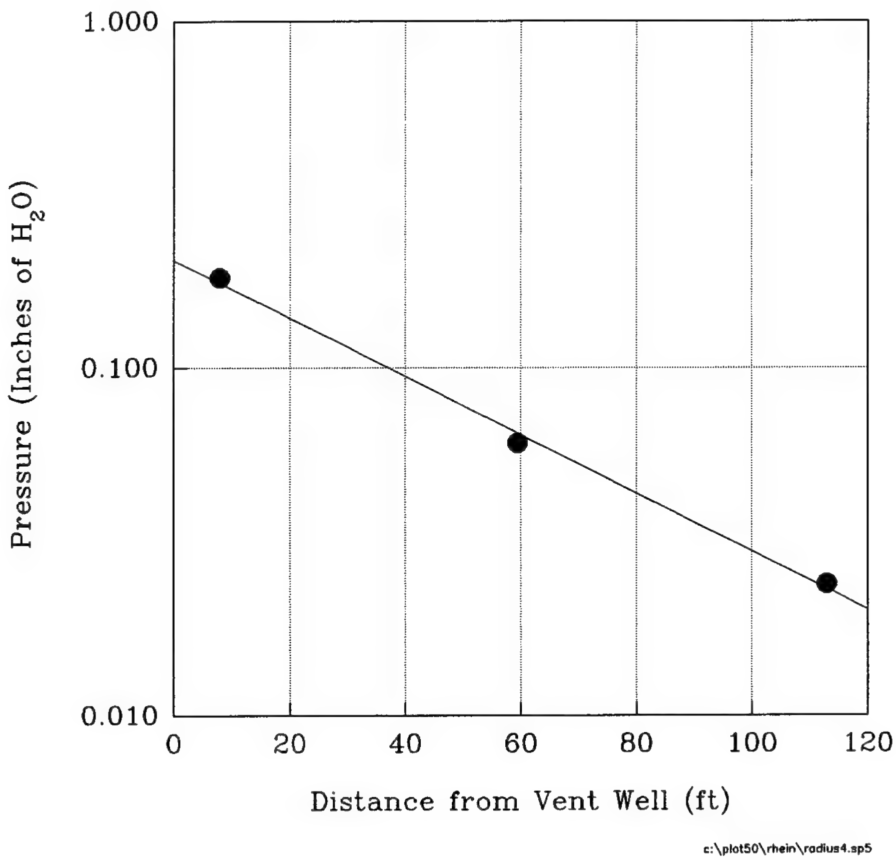


Figure D5. Radius of Influence at a Depth of 4 m at the Bioventing Test Plot

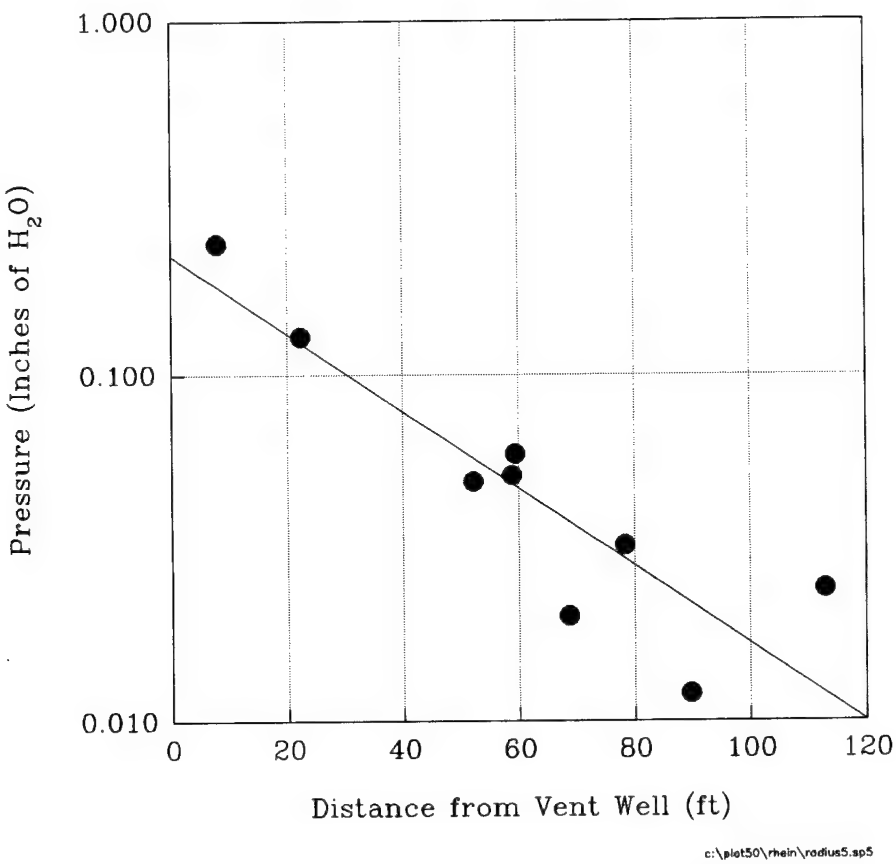


Figure D6. Radius of Influence at a Depth of 5 m at the Bioventing Test Plot

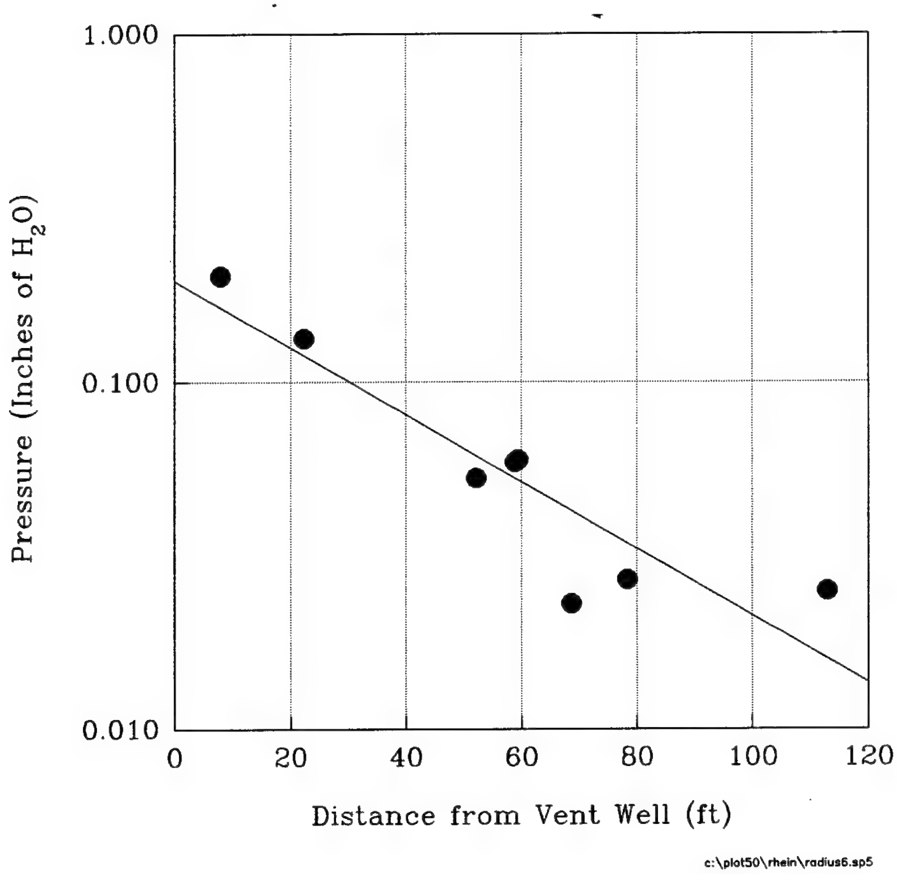


Figure D7. Radius of Influence at a Depth of 6 m at the Bioventing Test Plot

Projekt Rhein Main Air Base R 68.346

Date: 12-11-96 **Time:**

Weather: **Temperature:** -4°C

Messurement:

MPA	+1min	+35min	1:17h	2:00h	2:46h	3:44h	4:36h	
clean	.092	.108	.125	.121	.121	.125	.128	
black	.109	.118	.136	.132	.131	.138	.140	
brown	.124	.129	.146	.142	.139	.149	.149	
green	.160	.163	.179	.175	.172	.181	.182	
orange	.220	.218	.235	.230	.228	.236	.237	
red	.192	.188	.203	.201	.201	.206	.202	
yellow		–						
blue								

MPB	+2min	+37min	1:19h	2:02h	2:48	3:46h	4:38h	
clean	.087	0.091	.101	.102	.103	.109	.103	
black	.094	.094	.105	.107	.107	.114	.107	
brown	.105	.099	.110	.111	.112	.117	.111	
green	-.355	-.327	-.321	-.295	-.299	-.287	-.288	
orange	.123	.115	.130	.131	.129	.137	.129	
red	.126	.118	.132	.135	.128	.141	.134	
yellow								
blue								

MPC	+5min	+39min	1:22h	2:04	2:50h	3:48h	3:40	
clean	.044	0.033	.040	.057	.044	.053	.056	
black	.042	.034	.039	.058	.045	.053	.058	
brown	.043	.039	.045	.060	.048	.054	.060	
green	.048	.041	.046	.061	.050	.054	.061	
orange	.050	.044	.049	.064	.054	.056	.059	
red	.049	.045	.056	.064	.054	.061	.060	
yellow								
blue								

11/12 '96 15:10 +49 6196 936299 Battelle Ing.Tec -->00016144243667 Pg. 02

Date

MPD	+9 min	+41 min	1:25h	2:07h	2:54h	3:50	4:42	
clean	.016	.004	.023	.022	.010	.013	.022	
black	.010	.006	.024	.022	.010	.013	.021	
brown	.014	.009	.024	.023	.017	.014	.023	
green	.014	.007	.025	.023	.018	.019	.024	
orange	.014	.008	.027	.024	.017	.018	.024	
red	.017	.008	.025	.024	.018	.018	.025	
yellow								
blue								

zeroed

ckground	+29 min	1:01 h	1:37h	2:27h	3:15h	4:10h	5:09h	
clean	-0.013	0.00	-0.002	.001	.014	.014	.010	
black	-0.011	-0.003	-.003	-.002	.014	.014	.006	
brown	-0.012	-0.004	-.003	-.002	.017	.017	.008	
green	-0.010	-0.001	-.001	.001	.018	.019	.012	
orange	-0.013	-0.006	-.003	-.001	.015	.016	.012	
red	-0.012	-0.006	-.003	-.001	.018	.012	.012	
yellow	-0.013	-0.004	-.006	.001	.012	.012	.013	
blue	—							

GP1	+22 min	+54 min	1:46	2:19h	2:07	4:03h	4:54h	
white	0.025	.035	.020	.041	.032	.030	.102	
blue	0.040	.049	.036	.054	.048	.048	.040	
red	0.044	.057	.041	.063	.057	.056	.049	
yellow	0.045	.063	.045	.065	.062	.060	.053	

comes down -.048

GP2	+20 min	+52 min	1:38	2:17h	3:04h	4:00h	4:51	
white	0.017	.018	.013	.016	.015	.019	.019	
blue	0.032	.042	.028	.037	.037	.038	.045	
red	0.038	.049	.032	.043	.045	.046	.051	
yellow	0.047	.056	.042	.043	.052	.051	.059	

GP3	+17 min	+49 min	1:34h	2:14	3:01h	3:58h	4:49h	
white	+.180	-0.045	-.003	.010	.010	.012	●	
blue	+.034	-0.169	.034	.*	*	*	*	
red	.035	.027	.027	.037	.032	.039	.47	
yellow	—	—						

* drops down from .301 to -.020

● " " " .300 to .009

11/12 '96 15:10 +49 6196 936299 Battelle Ing.Tec -->000161442243667 Pg. 03

Tabelle1

GP4	+14 min	+47	1:32h	2:12h	2:59h	3:56h	4:48h	
white	.004	.004	.003	.010	.007	.008	.016	
blue	+.008	.013	.010	.024	.009	.020	.030	
red	.009	.010	.007	.025	.020	.021	.032	
yellow	.000	.005	.005	.021	.016	.018	.027	

GP5	+11 min	+45 min	1:28h	2:10h	2:57	3:59	4:46h	
white	-.145	0.001	.000	.001	.002	.000	.005	
blue	-.241	-0.002	-.010	.005	.003	.000	.009	
red	-.160	0.003	-.005	.006	.001	.001	.012	
yellow	-.170	0.180	.180	*	*	*	*	

failure! failure! *

GP8	+23 min	+56 min	1:44	2:22h	3:10h	4:06h	5:01h	
white	0.005	.007	.003	.012	.009	.019	.011	
blue	0.014	.019	.012	.023	.022	.029	.021	
red	0.014	.022	.012	.026	.024	.034	.020	
yellow	0.014	.022	.014	.029	.024	.032	.023	

* GOTAB down from .180 to -.064

APPENDIX E

MONTHLY SOIL GAS SAMPLING RESULTS

MPA

Depth (m)	O$_2$ (%)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	0.0	2.0	0.8	17.1	19.5	19.3	18.8	18.5	19.0	19.1	19.1	17.5	19.0	19.4	19.4		
2	NT	NT	0.0	0.0	0.3	20.5	20.9	20.7	20.3	20.0	20.5	20.3	20.1	20.0	20.1	20.9	20.9		
3	NT	NT	0.0	0.0	0.3	20.7	20.9	20.9	20.7	20.6	20.8	20.5	20.9	20.2	20.7	20.9	20.9		
4	NT	NT	0.0	0.0	4.2	20.9	20.9	20.9	20.8	20.7	20.8	20.5	20.9	20.5	20.5	20.9	20.9		
5	NT	NT	0.0	0.0	20.0	20.9	20.9	20.9	20.9	20.8	20.9	20.8	20.9	20.9	20.9	20.9	20.9		
6	NT	NT	0.0	0.0	20.0	20.9	20.9	20.9	20.8	20.7	20.9	20.8	20.9	20.9	20.9	20.9	20.9		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	CO$_2$ (%)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	15.5	13.6	15.5	3.3	1.3	1.3	1.3	2.0	2.0	1.5	1.5	7.4	2.0	2.2	2.3		
2	NT	NT	15.5	14.5	15.0	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.5	1.5	0.5	0.5	0.6		
3	NT	NT	15.0	14.1	15.0	0.5	0.5	0.4	0.3	0.3	0.5	0.4	0.3	0.8	0.4	0.1	0.3		
4	NT	NT	14.5	14.0	14.1	0.4	0.4	0.3	0.3	0.3	0.4	0.2	0.1	0.2	0.2	0.0	0.1		
5	NT	NT	13.1	12.5	2.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6	NT	NT	13.0	12.5	2.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	TPH (ppmv)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	1,080	800	840	720	620	680	660	740	620	460	640	460	460	200	120		
2	NT	NT	1,160	880	1,000	420	260	260	200	240	240	160	260	120	140	100	0		
3	NT	NT	1,200	920	1,120	400	260	260	140	200	220	180	140	120	120	60	0		
4	NT	NT	1,800	1,280	1,560	580	300	280	100	200	220	160	120	80	80	60	0		
5	NT	NT	4,720	3,000	1,400	120	100	140	0	100	140	60	40	20	40	20	0		
6	NT	NT	7,320	4,400	1,320	120	100	100	0	80	120	20	0	20	20	0	0		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

NT = Not Taken
* Groundwater prevents soil gas collection at deeper depth intervals
** Monitoring point not yet installed on first two sampling dates
*** Bold line represents startup of blower

MPB

Depth (m)	O2 (%) 11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	0.0	0.5	0.8	3.7	12.5	13.8	12.0	11.9	13.9	14.3	15.3	13.9	14.1	17.5	18.0		
2	NT	NT	0.0	0.0	0.0	12.1	17.0	17.0	16.8	17.1	17.8	17.9	18.2	18.1	17.8	18.0	18.7		
3	NT	NT	0.0	0.0	0.0	14.6	17.4	17.8	17.5	18.0	18.6	18.3	19.0	19.0	18.9	19.5	19.8		
4	NT	NT	0.0	0.0	0.0	18.3	19.5	19.5	19.8	19.9	20.0	19.8	20.0	20.3	19.7	20.0	20.1		
5	NT	NT	0.0	0.0	0.0	19.8	20.3	20.5	20.6	20.5	20.3	20.1	20.3	20.7	20.1	20.4	20.9		
6	NT	NT	0.0	0.0	0.0	20.1	20.5	20.5	20.8	20.6	20.5	20.2	20.8	20.8	20.0	20.4	20.9		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	CO2 (%) 11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	14.0	13.0	14.3	13.0	5.4	5.0	6.2	6.8	6.0	5.0	4.4	6.0	5.1	4.8	4.3		
2	NT	NT	14.0	13.0	14.2	8.5	3.1	3.2	3.3	2.0	2.6	2.3	2.0	2.5	2.0	2.5	2.8		
3	NT	NT	13.9	13.0	14.0	6.7	3.0	2.9	3.0	2.3	2.1	1.8	1.7	1.5	1.6	1.0	1.9		
4	NT	NT	13.0	12.3	13.5	3.2	1.2	1.0	1.0	0.8	0.8	0.6	0.6	0.7	0.6	0.6	0.8		
5	NT	NT	12.5	12.0	13.0	1.5	0.7	0.6	0.5	0.4	0.5	0.4	0.1	0.4	0.3	0.5	0.7		
6	NT	NT	12.5	12.0	13.0	1.0	0.6	0.6	0.5	0.3	0.5	0.1	0.1	0.2	0.0	0.3	0.6		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	TPH (ppmv) 11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	7,880	5,400	5,640	5,800	3,700	3,620	3,540	3,720	3,600	2,780	3,180	1,740	1,800	600	480		
2	NT	NT	8,880	6,080	6,000	3,860	2,380	1,960	1,660	1,460	1,660	1,160	1,360	600	1,000	400	240		
3	NT	NT	8,720	6,120	6,040	3,860	2,620	1,860	1,540	1,340	1,280	1,020	1,180	520	600	400	180		
4	NT	NT	8,440	5,920	5,800	1,920	380	400	280	320	360	200	340	120	140	140	100		
5	NT	NT	8,600	5,960	5,840	1,080	240	220	80	160	240	100	180	60	80	80	0		
6	NT	NT	8,800	6,000	5,800	1,220	240	200	60	120	220	60	40	20	20	0	0		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	Temperature (°C) 11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	13.6	13.1	12.5	12.1	13.8	14.8	16.9	21.9	23.4	20.6	20.2	21.2	20.5	20.0	8.2		
2	NT	NT	10.8	11.9	11.2	11.2	12.2	13.1	14.0	16.4	18.1	18.7	18.4	18.9	18.5	18.2	12.3		
3	NT	NT	9.6	11.0	10.5	10.6	11.3	12.1	12.5	18.4	15.1	16.4	16.8	17.5	16.1	16.0	13.9		
4	NT	NT	9.2	10.4	9.9	10.0	10.6	11.2	11.6	12.3	13.0	13.7	14.4	15.7	13.5	13.5	14.9		
5	NT	NT	9.4	10.2	9.8	10.1	10.4	10.9	11.2	11.6	12.0	12.6	11.5	14.6	12.6	12.6	15.0		
6	NT	NT	9.4	10.5	10.1	10.3	10.4	10.6	10.9	11.0	11.3	12.0	11.7	13.6	11.8	12.6	14.9		
7	NT	NT	10.4	11.0	11.0	10.4	10.6	10.7	11.0	11.0	11.2	11.4	11.3	12.3	11.4	12.2	14.5		
8	NT	NT	10.9	11.5	10.8	10.8	10.8	11.0	11.1	11.4	11.5	NT	11.2	11.9	NT	12.3	14.0		

NT = Not Taken
* Groundwater prevents soil gas collection at deeper depth intervals
** Monitoring point not yet installed on first two sampling dates
*** Bold line represents startup of blower

MPC

Depth (m)	O_2 (%)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	6.2	7.0	3.0	15.8	19.1	19.3	19.2	18.5	18.3	19.1	19.1	19.1	19.0	20.0	20.2		
2	NT	NT	2.5	4.0	0.2	20.0	20.2	20.3	20.6	20.0	20.6	20.5	20.1	20.3	20.3	20.6	20.8		
3	NT	NT	0.0	0.5	0.0	20.6	20.6	20.6	20.9	20.3	20.9	20.8	20.5	20.6	20.8	20.8	20.9		
4	NT	NT	0.0	0.0	0.0	20.8	20.7	20.5	20.9	20.3	20.9	20.9	20.6	20.8	20.9	20.9	20.9		
5	NT	NT	0.0	0.0	5.5	20.8	20.9	20.5	20.9	20.6	20.9	20.9	20.7	20.9	20.9	20.9	20.9		
6	NT	NT	0.0	0.0	2.5	20.8	20.9	20.5	20.9	20.6	20.9	20.9	20.7	20.9	20.9	20.9	20.9		
7	NT	NT	0.0	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	CO_2 (%)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	10.5	10.3	12.8	5.0	1.5	1.3	1.5	1.8	1.8	1.6	1.5	1.8	1.6	1.5	1.5		
2	NT	NT	12.8	11.9	14.5	0.8	0.7	0.7	0.6	0.7	0.7	0.6	0.6	0.6	0.6	0.5	0.5		
3	NT	NT	14.5	13.8	14.5	0.6	0.4	0.4	0.3	0.1	0.3	0.2	0.1	0.2	0.2	0.0	0.0		
4	NT	NT	14.1	13.4	14.0	0.5	0.3	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0		
5	NT	NT	14.0	13.0	13.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6	NT	NT	13.8	12.9	13.0	0.5	0.4	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0		
7	NT	NT	14.0	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	TPH (ppmv)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	680	740	560	740	520	400	280	380	340	240	340	180	200	100	100		
2	NT	NT	680	740	720	540	400	400	240	380	320	200	300	100	120	40	40		
3	NT	NT	1800	1120	1360	780	560	480	300	340	320	160	260	80	80	0	0		
4	NT	NT	2400	1640	1720	800	480	380	200	260	260	120	200	40	20	0	0		
5	NT	NT	2480	1600	1840	440	200	180	20	120	200	60	120	20	0	0	0		
6	NT	NT	2400	1600	1920	320	100	120	20	120	200	20	80	20	0	0	0		
7	NT	NT	2280	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	Temperature (°C)																	
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2	NT	NT	11.0	11.4	11.3	11.2	11.5	12.4	13.0	15.0	16.4	16.5	16.9	17.9	16.5	16.0	11.4		
4	NT	NT	9.7	10.0	9.8	10.1	10.5	10.9	11.2	11.7	12.1	12.7	13.5	15.1	15.0	15.0	13.5		
6	NT	NT	10.3	10.3	10.2	10.2	10.3	10.5	10.8	11.2	11.0	11.1	11.5	12.7	12.5	12.4	13.7		
8	NT	NT	11.1	11.2	10.8	11.0	10.8	11.1	11.1	11.4	10.9	11.1	11.2	11.6	11.6	NT	13.4		

NT = Not Taken
* Groundwater prevents soil gas collection at deeper depth intervals
** Monitoring point not yet installed on first two sampling dates
*** Bold line represents startup of blower

MPD

Depth (m)	O$_2$ (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	10.0	10.9	10.5	9.0	20.0	20.1	20.5	20.7	20.2	20.2	20.1	20.0	20.2	20.5	20.9		
2	NT	NT	9.0	9.8	9.8	10.2	20.1	20.2	20.8	20.8	20.5	20.3	20.3	20.0	20.2	20.9	20.9		
3	NT	NT	5.0	6.8	6.0	14.0	20.2	20.2	20.8	20.9	20.8	20.3	20.3	20.1	20.3	20.9	20.9		
4	NT	NT	4.5	6.0	5.3	11.8	20.2	20.2	20.9	20.9	20.8	20.4	20.3	20.1	20.4	20.9	20.9		
5	NT	NT	4.0	4.9	4.5	9.2	20.2	20.2	20.8	20.9	20.8	20.6	20.4	20.2	20.3	20.9	20.9		
6	NT	NT	3.8	4.2	4.2	9.8	20.0	20.2	20.8	20.8	20.7	20.7	20.4	20.2	20.4	20.9	20.9		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	20.9		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	CO$_2$ (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	8.8	8.0	9.0	8.8	2.6	1.0	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.5	0.6		
2	NT	NT	9.5	8.9	10.0	9.2	2.0	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.5	0.5		
3	NT	NT	11.0	10.1	11.0	9.2	1.2	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.2		
4	NT	NT	11.5	10.7	11.8	8.5	2.0	0.7	0.6	0.5	0.5	0.5	0.4	0.3	0.2	0.2	0.2		
5	NT	NT	11.8	11.0	12.0	9.0	2.1	0.9	0.7	0.6	0.5	0.5	0.5	0.2	0.0	0.2	0.2		
6	NT	NT	12.0	11.0	12.0	8.5	2.5	0.9	0.7	0.7	0.7	0.6	0.6	0.5	0.0	0.2	0.3		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.3		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	TPH (ppmv)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	320	320	260	640	260	180	100	220	180	120	180	180	160	100	40		
2	NT	NT	640	560	440	420	220	180	60	160	180	120	180	140	120	80	20		
3	NT	NT	600	560	400	660	180	160	40	120	160	100	140	100	100	80	0		
4	NT	NT	600	560	400	540	220	160	40	120	160	60	140	60	20	0	0		
5	NT	NT	600	560	400	640	240	160	40	120	160	20	100	40	0	0	0		
6	NT	NT	560	560	400	560	240	160	60	100	160	40	100	40	0	0	0		
7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT		

Depth (m)	Temperature (°C)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	12.7	12.3	12.1	11.8	12.8	14.5	15.7	20.3	20.9	17.8	17.7	19.5	19.5	19.0	6.9		
4	NT	NT	9.0	9.5	9.4	9.6	9.9	10.6	10.6	11.2	11.8	12.4	13.1	15.0	15.0	14.8	11.2		
6	NT	NT	10.1	10.0	9.9	10.0	10.1	10.3	10.5	10.2	10.6	10.8	11.3	12.6	12.8	12.6	13.4		

NT = Not Taken
* Groundwater prevents soil gas collection at deeper depth intervals
** Monitoring point not yet installed on first two sampling dates
*** Bold line represents startup of blower

Background

Depth (m)	O₂ (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	NT	NT	NT	NT	NT	18.8	18.5	18.5	18.5	18.3	18.0	17.8	17.7	18.0	18.1		
2	NT	NT	NT	NT	NT	NT	NT	18.5	18.2	18.0	18.1	18.0	18.0	17.8	17.7	18.3	18.4		
3	NT	NT	NT	NT	NT	NT	NT	18.3	18.1	18.0	18.2	18.0	18.0	17.8	17.8	18.0	18.2		
4	NT	NT	NT	NT	NT	NT	NT	18.3	18.0	18.0	18.2	18.0	18.0	17.8	18.0	18.0	18.0		
5	NT	NT	NT	NT	NT	NT	NT	18.0	18.2	18.0	18.2	18.0	18.0	17.9	18.0	18.0	18.0		
6	NT	NT	NT	NT	NT	NT	NT	18.2	18.0	17.8	18.2	18.1	18.1	17.9	17.0	18.0	17.9		
7	NT	NT	NT	NT	NT	NT	NT	18.3	18.0	17.8	18.2	17.9	18.0	17.9	17.8	17.9	17.8		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	17.9	NT	NT	NT		

Depth (m)	CO_2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	NT	NT	NT	NT	NT	3.8	3.9	4.2	4.1	4.4	4.2	4.6	4.1	4.0	4.0		
2	NT	NT	NT	NT	NT	NT	NT	3.6	3.9	4.2	4.0	4.5	4.2	4.5	4.0	3.9	4.0		
3	NT	NT	NT	NT	NT	NT	NT	3.9	4.0	4.2	4.0	4.5	4.3	4.5	4.1	4.5	4.5		
4	NT	NT	NT	NT	NT	NT	NT	4.0	3.9	4.1	3.9	4.4	4.2	4.3	4.3	4.5	4.6		
5	NT	NT	NT	NT	NT	NT	NT	3.9	3.8	4.1	3.9	4.2	4.2	4.3	4.3	4.6	4.8		
6	NT	NT	NT	NT	NT	NT	NT	3.8	3.9	4.2	3.9	4.2	4.1	4.3	4.3	4.6	4.8		
7	NT	NT	NT	NT	NT	NT	NT	3.7	3.8	4.1	3.9	4.2	4.3	4.2	4.3	4.6	4.8		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	4.2	NT	NT	NT		

Depth (m)	TPH (ppmv)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1	NT	NT	NT	NT	NT	NT	NT	240	240	300	260	200	320	240	240	240	240		
2	NT	NT	NT	NT	NT	NT	NT	260	220	280	260	180	320	240	240	240	240		
3	NT	NT	NT	NT	NT	NT	NT	260	220	280	240	180	320	220	240	240	260		
4	NT	NT	NT	NT	NT	NT	NT	260	220	260	240	180	300	220	240	240	260		
5	NT	NT	NT	NT	NT	NT	NT	260	220	220	220	160	300	200	220	260	280		
6	NT	NT	NT	NT	NT	NT	NT	280	220	260	240	160	300	200	220	240	260		
7	NT	NT	NT	NT	NT	NT	NT	280	220	260	220	160	300	200	200	260	280		
8	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	200	NT	NT	NT		

Depth (m)	Temperature (°C)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2	NT	NT	NT	NT	NT	NT	NT	11.5	11.8	14.1	14.8	15.2	15.6	16.9	18.0	18.0	11.2		
4	NT	NT	NT	NT	NT	NT	NT	10.2	10.1	11.0	11.3	12.0	12.4	13.9	14.0	14.5	13.3		
6	NT	NT	NT	NT	NT	NT	NT	10.4	10.4	10.9	10.8	11.2	11.6	12.6	12.5	13.4	13.4		
8	NT	NT	NT	NT	NT	NT	NT	11.2	11.0	11.4	11.3	11.7	11.9	11.6	11.5	13.2	13.0		

NT = Not Taken
* Groundwater prevents soil gas collection at deeper depth intervals
** Bold line represents startup of blower

GP1

Depth	O_2 (%)																		
(m)	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1.80	6.0	6.2	NT	6.8	0.8	17.0	14.5	19.9	19.2	19.8	20.1	19.0	19.0	19.1	19.2	20.0	20.0		
3.25	0.5	0.0	NT	1.0	0.0	17.9	19.4	20.0	19.7	20.0	20.0	20.0	19.8	20.1	20.0	20.3	20.2		
4.80	0.5	0.9	NT	0.0	0.0	19.2	20.0	20.2	20.0	20.5	20.1	20.2	20.0	20.5	20.2	20.2	20.2		
6.30	NT	0.0	NT	0.0	0.0	18.5	19.9	20.1	20.0	20.2	20.1	20.2	20.1	20.6	20.3	20.1	20.0		

Depth	CO_2 (%)																		
(m)	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/96/96	11/25/96		
1.80	10.5	9.0	NT	10.0	14.0	3.7	1.0	1.0	1.1	1.5	0.6	1.5	1.5	1.5	1.4	1.3	1.3		
3.25	14.0	11.5	NT	12.3	13.9	3.3	1.2	0.9	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.8	0.7		
4.80	15.0	11.2	NT	12.0	13.0	1.5	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.5	0.5	0.7	0.7		
6.30	NT	11.2	NT	11.6	12.8	2.5	0.8	0.7	0.8	0.7	0.6	0.6	0.5	0.4	0.3	1.0	1.1		

Depth	TPH (ppmv)																		
(m)	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1.80	420	800	NT	560	760	2,180	1,440	1,220	1,020	1,020	240	720	1,040	520	300	200	160		
3.25	1,400	1,360	NT	880	1,640	2,900	800	540	380	480	300	320	440	160	120	120	100		
4.80	2,400	2,480	NT	2,280	3,160	2,440	620	360	240	360	240	160	340	100	100	80	80		
6.30	NT	3,000	NT	2,680	3,120	2,800	760	400	300	340	260	120	340	100	120	100	180		

GP2

Depth	O_2 (%)																		
(m)	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.50	5.0	11.0	NT	4.8	4.0	20.1	20.5	20.6	20.5	20.8	20.6	20.6	20.5	20.3	20.6	20.6	20.8		
3.25	2.0	1.9	NT	3.5	6.3	20.9	20.8	20.9	20.8	20.9	20.7	20.9	20.6	20.8	20.5	20.6	20.8		
4.95	0.5	0.0	NT	2.0	19.0	20.9	20.9	20.9	20.8	20.9	20.7	20.8	20.6	20.9	20.7	20.8	20.9		
6.55	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	20.5	NT	NT	NT	20.9	20.7	20.5		

Depth	CO_2 (%)																		
(m)	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.50	6.5	6.2	NT	12.8	11.2	0.8	0.5	0.5	0.5	0.5	0.4	0.3	0.5	0.6	0.2	0.3	0.7		
3.25	13.0	10.2	NT	10.8	12.0	0.0	0.2	0.0	0.0.	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.3		
4.95	13.4	11.0	NT	10.8	3.3	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6.55	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.5	NT	NT	NT	0.0	0.0	0.0		

Depth	TPH (ppmv)																		
(m)	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.50	300	640	NT	260	520	220	120	100	60	200	180	120	60	80	80	40	0		
3.25	480	840	NT	560	560	80	60	80	0	160	160	100	40	20	80	20	0		
4.95	1,460	880	NT	560	220	80	60	80	0	160	160	80	20	20	40	20	0		
6.55	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	180	NT	NT	NT	0	0	0		

NT = Not Taken
* Groundwater prevents soil gas collection at deeper depth intervals
** Bold line represents startup of blower

GP3

Depth (m)	O2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	6.0	12.1	NT	13.0	9.8	20.9	20.9	20.8	20.9	20.9	20.8	20.6	20.5	20.5	20.9	20.9	20.9		
3.50	4.0	3.5	NT	6.0	18.0	20.9	20.9	20.7	20.9	20.9	20.9	20.6	20.6	20.7	20.9	20.9	20.9		
4.95	2.0	2.2	NT	5.5	20.9	20.8	20.9	20.4	20.9	20.9	20.9	20.7	20.6	20.8	20.9	20.9	20.9		
6.50	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	20.9	20.8	20.6	NT	20.5	20.9	20.5		

Depth (m)	CO2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/96/96	11/25/96		
2.00	13.0	5.3	NT	6.2	8.7	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0		
3.50	12.0	9.5	NT	9.8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
4.95	10.0	10.0	NT	9.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6.50	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.0	0.0	0.0	NT	0.0	0.0	0.0		

Depth (m)	TPH (ppmv)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	380	640	NT	260	400	80	40	80	0	200	140	100	60	80	80	80	0		
3.50	420	800	NT	520	180	80	40	80	0	160	160	100	60	60	80	80	0		
4.95	420	800	NT	520	60	80	60	100	20	160	160	40	80	60	40	60	0		
6.50	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	140	80	40	NT	40	40	0		

GP4

Depth (m)	O2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	16.0	15.5	NT	16.5	14.4	20.5	20.8	20.8	20.9	20.9	20.8	20.9	20.8	20.7	20.9	20.9	20.9		
3.50	5.0	5.2	NT	7.0	6.0	20.9	20.9	20.8	20.9	20.9	20.8	20.9	20.8	20.9	20.9	20.9	20.9		
5.00	4.0	4.5	NT	6.0	7.1	20.9	20.9	20.9	20.9	20.9	20.8	20.8	20.8	20.9	20.9	20.9	20.9		
6.50	NT	NT	NT	NT	NT	NT	NT	NT	NT	20.9	20.8	NT	20.5	NT	20.5	20.9	20.9		

Depth (m)	CO2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	4.5	4.0	NT	4.5	5.5	2.2	0.6	0.4	0.2	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0		
3.50	12.0	9.5	NT	9.5	10.5	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
5.00	12.5	9.9	NT	9.8	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6.50	NT	NT	NT	NT	NT	NT	NT	NT	NT	0.0	0.0	NT	0.0	NT	0.0	0.0	0.0		

Depth (m)	TPH (ppmv)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	320	520	NT	260	200	200	80	100	20	140	80	100	160	80	40	40	0		
3.50	460	800	NT	560	440	80	60	80	20	140	80	120	160	20	40	20	0		
5.00	480	760	NT	560	440	80	40	80	0	120	60	120	180	0	80	40	0		
6.50	NT	NT	NT	NT	NT	NT	NT	NT	NT	120	60	NT	200	NT	100	60	0		

NT = Not Taken

* Groundwater prevents soil gas collection at deeper depth intervals

** Bold line represents startup of blower

GP5

Depth (m)	O₂ (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1.85	15.0	14.5	NT	16.5	14.9	17.5	20.3	20.2	20.9	20.9	20.7	20.9	20.4	20.5	20.9	20.9	20.9		
3.40	6.0	6.2	NT	8.0	7.0	20.5	20.8	20.6	20.9	20.9	20.9	20.9	20.6	20.9	20.9	20.9	20.9		
4.75	6.0	5.5	NT	7.0	5.5	20.8	20.9	20.6	20.9	20.9	20.9	20.2	20.7	20.9	20.8	20.9	20.9		
6.10	5.0	4.2	NT	7.0	5.5	20.5	20.7	20.5	20.9	20.5	20.9	20.9	20.2	20.9	20.8	20.9	20.9		

Depth (m)	CO_2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/96/96	11/25/96		
1.85	5.0	4.5	NT	4.7	5.1	6.5	1.5	0.7	0.6	0.7	0.5	0.0	0.5	0.5	0.0	0.0	0.1		
3.40	12.0	9.2	NT	9.2	10.1	1.5	0.5	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
4.75	11.0	9.9	NT	9.5	10.8	0.5	0.3	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0		
6.10	12.2	9.5	NT	9.5	10.5	0.5	0.5	0.0	0.1	0.2	0.2	0.0	0.1	0.1	0.0	0.1	0.1		

Depth (m)	TPH (ppmv)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
1.85	320	760	NT	260	260	280	160	140	60	200	100	40	140	60	20	0	0		
3.40	440	840	NT	560	560	180	60	80	0	200	80	100	120	20	80	40	0		
4.75	400	760	NT	560	560	80	60	80	0	200	60	120	120	0	80	60	0		
6.10	2,200	19,920	NT	560	560	100	60	80	20	200	80	140	160	160	80	40	0		

GP8

Depth (m)	O₂ (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	7.0	9.5	NT	9.0	5.5	19.5	20.1	20.2	20.0	20.8	20.7	20.8	20.1	20.6	20.9	20.9	20.9		
3.50	1.0	2.5	NT	1.8	0.5	20.0	20.2	20.4	20.2	20.8	20.5	20.9	20.2	20.8	20.9	20.9	20.9		
5.00	0.5	0.1	NT	0.8	0.5	19.1	20.2	20.4	20.2	20.9	20.7	20.9	20.2	20.8	20.9	20.9	20.8		
6.50	NT	0.0	NT	0.7	0.0	19.8	20.5	20.5	20.6	20.9	20.7	20.9	20.2	20.9	20.9	20.8	20.8		

Depth (m)	CO_2 (%)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	9.2	7.1	NT	8.6	10.9	1.9	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.3	0.3	0.3		
3.50	14.0	10.2	NT	11.2	12.8	0.8	0.6	0.6	0.5	0.5	0.3	0.3	0.4	0.2	0.2	0.1	0.2		
5.00	14.0	8.2	NT	11.1	12.2	1.9	0.6	0.5	0.4	0.7	0.3	0.3	0.1	0.1	0.3	0.2	0.1		
6.50	NT	11.5	NT	11.2	12.5	1.3	0.6	0.5	0.4	0.5	0.1	0.3	0.1	0.0	0.1	0.1	0.0		

Depth (m)	TPH (ppmv)																		
	11/14/95	3/29/96	5/3/96	5/10/96	5/10/96	5/13/96	5/21/96	5/28/96	6/3/96	6/13/96	6/20/96	6/27/96	7/3/96	8/21/96	9/19/96	10/29/96	11/25/96		
2.00	440	480	NT	740	600	960	220	180	80	200	100	40	180	80	40	40	40		
3.50	560	560	NT	600	600	980	280	220	80	200	100	20	160	60	20	20	20		
5.00	1,080	840	NT	840	800	620	180	160	60	200	100	0	140	40	20	20	20		
6.50	NT	960	NT	920	1,040	700	240	180	60	200	80	0	140	60	20	20	20		

NT = Not Taken

* Groundwater prevents soil gas collection at deeper depth intervals

** Bold line represents startup of blower

APPENDIX F

RESULTS FROM IN SITU RESPIRATION TESTS

AUGUST 1996 IN SITU RESPIRATION TEST RAW DATA

08/26/96

Tab1

Calibration: wheater: cloudy

O2 gas	9.97%		instrument	10.2%
CO2 gas	10.02%		instrument	10.0%

Hexan gas	3983ppm		instrument	4040ppm

Messurement:

Backgr.	O2	CO2	TPH	GT202 / O2	Temp.
clean	18.0%	4.0%	300ppm	17.9%	—
black	17.9	4.1	300	17.8	17.4°C
brown	17.9	3.9	300	17.8	—
green	18.0	3.9	280	17.9	14.3
orange	17.9	3.6	280	17.8	—
red	18.1	3.5	260	18.0	12.8
yellow	18.1	3.4	260	17.9	—
blue		groundwater			11.9

MPA	O2	CO2	TPH	GT202 / O2
clean -1	17.0	1.8	440	17.1
black -2	20.1	0.5	200	20.4
brown -3	20.4	0.3	180	20.5
green -4	20.5	0.1	140	20.6
orange -5	20.6	0.0	80	20.7
red -6	20.8	0.0	60	20.9
yellow -7		groundwater		
blue -8		groundwater		

MPB	O2	CO2	TPH	GT202 / O2	Temp.
clean	14.2	5.0	1960	15.0	22.5
black	18.3	1.9	720	18.6	20.4
brown	19.1	1.3	600	19.3	18.4
green	20.0	0.6	200	20.2	16.7
orange	20.5	0.2	100	20.5	15.4
red	20.6	0.0	60	20.5	14.1
yellow		groundwater			13.3
blue		groundwater			12.7

Tab1 08/26/96

MPC	O2	CO2	TPH	GT202 / O2	Temp.
clean	19.1	5.0	200	19.2	—
black	20.2	1.9	120	20.2	18.8
brown	20.5	1.3	100	20.4	—
green	20.6	0.6	60	20.5	15.6
orange	20.7	0.2	40	20.5	—
red	20.7	0.0	20	20.6	13.2
yellow		groundwater			—
blue		groundwater			12.4

MPD	O2	CO2	TPH	GT202 / O2	Temp.
clean	20.3	1.5	120	20.3	20.4
black	20.5	0.5	100	20.4	—
brown	20.5	0.1	80	20.5	—
green	20.5	0.0	60	20.5	15.2
orange	20.7	0.0	40	20.6	—
red	20.7	0.0	40	20.7	12.8
yellow		groundwater			—
blue		groundwater			—

GP1	O2	CO2	TPH	GT202 / O2
white	19.1	1.4	360	19.3
blue	20.1	0.7	140	20.2
red	20.4	0.5	60	20.4
yellow	20.5	0.4	60	20.5

GP2	O2	CO2	TPH	GT202 / O2
white	20.2	0.5	100	20.1
blue	20.5	0.0	40	20.5
red	20.6	0.0	40	20.6
yellow		groundwater		

GP3	O2	CO2	TPH	GT202 / O2
white	20.7	0.0	60	20.6
blue	20.8	0.0	40	20.6
red	20.9	0.0	40	20.7
yellow		groundwater		

08/26/96

Tab1

GP4	O2	CO2	TPH	GT202 / O2
white	20.9	0.0	60	20.7
blue	20.8	0.0	40	20.6
red	20.8	0.0	20	20.7
yellow	groundwater			

GP5	O2	CO2	TPH	GT202 / O2
white	20.7	0.4	80	20.7
blue	20.9	0.0	40	20.9
red	20.9	0.0	20	20.9
yellow	20.8	0.0	60	20.7

GP8	O2	CO2	TPH	GT202 / O2
white	20.5	0.4	80	20.5
blue	20.6	0.2	80	20.5
red	20.7	0.0	40	20.6
yellow	20.5	0.0	100	20.5

08/27/96

Tab1

Calibration: wheater: cloudy

O2 gas	9.97 %		instrument	10.2 %
CO2 gas	10.02 %		instrument	10.0 %

Hexan gas	3983 ppm		instrument	3940 ppm

Messurement:

Backgr.	O2	CO2	TPH	GT202 / O2	Temp.
clean	17.8 %	4.2 %	240 ppm	17.7 %	—
black	17.9	4.0	260	17.7	17.5 °C
brown	17.8	4.1	260	17.7	—
green	18.0	4.0	260	17.7	14.4
orange	18.0	3.9	260	17.7	—
red	18.1	3.8	260	17.6	12.7
yellow	18.0	3.8	260	17.6	—
blue		groundwater			11.6

MPA	O2	CO2	TPH	GT202 / O2
clean	15.0	4.0	420	14.5
black	17.9	1.6	200	17.5
brown	18.6	1.0	200	18.3
green	19.7	0.8	160	19.3
orange	19.8	0.5	100	19.4
red	20.1	0.4	40	20.2
yellow		groundwater		
blue		groundwater		

MPB	O2	CO2	TPH	GT202 / O2	Temp.
clean	12.0	6.2	2280	11.5	22.4
black	15.0	3.8	840	14.5	20.0
brown	17.5	2.1	680	17.2	18.5
green	19.5	0.7	180	19.5	16.6
orange	20.0	0.5	80	19.9	15.3
red	20.4	0.3	0	20.4	13.9
yellow		groundwater			13.1
blue		groundwater			12.7

08/27/96

Tab1

MPC	O2	CO2	TPH	GT202 / O2	Temp.
clean	19.0	1.6	180	19.1	—
black	19.8	0.9	140	19.8	18.8
brown	20.2	0.7	100	20.4	[illegible]
green	20.5	0.3	40	20.9	15.7
orange	20.9	0.0	0	20.9	—
red	20.9	0.0	0	20.8	13.3
yellow		groundwater			—
blue		groundwater			12.3

MPD	O2	CO2	TPH	GT202 / O2	Temp.
clean	20.5	0.7	100	20.4	20.2
black	20.5	0.5	100	20.4	—
brown	20.7	0.4	60	20.6	—
green	20.8	0.4	40	20.6	15.3
orange	20.8	0.3	40	20.7	—
red	20.8	0.5	40	20.7	13.0
yellow		groundwater			—
blue		groundwater			—

GP1	O2	CO2	TPH	GT202 / O2
white	17.8	2.6	420	17.4
blue	19.2	0.8	160	19.2
red	20.0	0.5	100	20.2
yellow	20.5	0.2	80	20.4

GP2	O2	CO2	TPH	GT202 / O2
white	19.5	1.2	160	19.5
blue	20.7	0.0	40	20.7
red	20.8	0.0	40	20.7
yellow		groundwater		

GP3	O2	CO2	TPH	GT202 / O2
white	20.6	0.1	80	20.5
blue	20.9	0.0	40	20.8
red	20.9	0.0	40	20.8
yellow		groundwater		

Tab1

08/27/96

GP4	O2	CO2	TPH	GT202 / O2
white	21.7	0.2	80	20.5
blue	20.9	0.0	60	20.7
red	20.9	0.0	40	20.8
yellow		groundwater		

GP5	O2	CO2	TPH	GT202 / O2
white	20.5	0.6	100	20.4
blue	20.9	0.0	80	20.8
red	20.9	0.0	100	20.8
yellow	20.7	0.1	200	20.7

GP8	O2	CO2	TPH	GT202 / O2
white	20.0	0.5	120	20.1
blue	20.5	0.0	80	20.5
red	20.5	0.0	60	20.5
yellow	20.5	0.0	100	20.5

Tab1

08/28/96

Calibration:

wheater: cloudy / raining

O2 gas	9.97%		instrument	10.0%
CO2 gas	10.02%		instrument	10.0%

Hexan gas	3983 ppm		instrument	3920 ppm

Messurement:

Backgr.	O2	CO2	TPH	GT202 / O2	Temp.
clean	17.6%	4.4%	160 ppm	17.3%	–
black	17.3	4.4	160	17.2	17.5°C
brown	17.5	4.3	160	17.2	–
green	17.5	4.2	160	17.2	14.4°C
orange	17.5	4.2	160	17.2	–
red	17.5	4.2	160	17.2	12.8
yellow	17.5	4.2	160	17.2	–
blue		groundwater			11.9

MPA	O2	CO2	TPH	GT202 / O2
clean	17.7	5.8	400	11.4
black	16.0	2.9	220	15.9
brown	17.2	2.0	180	16.8
green	18.8	1.1	140	18.6
orange	19.2	0.7	80	19.3
red	20.0	0.5	60	20.2
yellow		groundwater		
blue		groundwater		

w.D. = with Deluder

MPB	O2	CO2	TPH	GT202 / O2	Temp.
clean	9.5	7.2	1680 w.D	11.1 w.D	22.4
black	12.5	5.0	880	10.5	20.1
brown	15.1	3.1	700	14.2	18.4
green	18.4	0.9	180	18.4	16.6
orange	19.2	0.6	100	19.5	15.4
red	20.0	0.4	60	20.2	14.0
yellow		groundwater			13.1
blue		groundwater			12.3

Tab1 08/28/96

MPC	O2	CO2	TPH	GT202 / O2	Temp.
clean	19.0	1.8	160	18.7	—
black	19.2	1.1	120	18.8	18.7
brown	19.5	0.8	100	19.3	—
green	20.2	0.5	60	20.2	15.7
orange	20.8	0.2	40	20.7	—
red	20.9	0.0	20	20.9	13.4
yellow		groundwater			—
blue		groundwater			12.1

MPD	O2	CO2	TPH	GT202 / O2	Temp.
clean	20.6	0.7	80	20.6	20.4
black	20.8	0.5	40	20.7	—
brown	20.9	0.3	40	20.9	—
green	20.9	0.2	40	20.9	16.3
orange	20.9	0.2	40	20.9	—
red	20.9	0.5	40	20.9	12.9
yellow		groundwater			—
blue		groundwater			—

GP1	O2	CO2	TPH	GT202 / O2
white	17.7	3.0	300	17.5
blue	18.5	1.2	140	17.8
red	20.0	0.6	60	19.8
yellow	20.5	0.4	40	20.4

GP2	O2	CO2	TPH	GT202 / O2
white	19.5	1.3	120	19.0
blue	20.5	0.0	20	20.5
red	20.7	0.0	20	20.7
yellow		groundwater		

GP3	O2	CO2	TPH	GT202 / O2
white	20.5	0.5	40	20.5
blue	20.9	0.0	0	20.9
red	20.9	0.0	0	20.9
yellow		groundwater		

Tab1 08/28/96

GP4	O2	CO2	TPH	GT202 / O2
white	20.6	0.4	40	20.6
blue	20.9	0.0	20	20.9
red	20.9	0.0	20	20.9
yellow		groundwater		

GP5	O2	CO2	TPH	GT202 / O2
white	20.6	0.6	60	20.5
blue	20.9	0.0	0	20.9
red	20.9	0.0	0	20.9
yellow	20.9	0.0	20	20.9

GP8	O2	CO2	TPH	GT202 / O2
white	19.8	0.8	100	19.5
blue	20.6	0.1	20	20.6
red	20.8	0.0	20	20.6
yellow	20.8	0.0	40	20.8

Tab1

Calibration: wheater: cloudy 08/29/96

O2 gas	9.97%		instrument	10.2%
CO2 gas	10.02%		instrument	9.9%

Hexan gas	3983ppm		instrument	3780ppm

Messurement:

Backgr.	O2	CO2	TPH	GT202 / O2	Temp.
clean	17.9%	4.4%	200ppm	18.0%	—
black	17.8	4.4	200	17.8	17.7°C
brown	17.9	4.3	200	18.0	—
green	17.9	4.2	200	18.0	14.4
orange	17.9	4.2	200	18.0	—
red	17.9	4.2	200	18.1	12.8
yellow	18.0	4.2	200	18.1	—
blue		groundwater			11.9

MPA	O2	CO2	TPH	GT202 / O2
clean	9.8	7.1	300 w.D.	14.6 w.D
black	13.1	4.3	220	13.2
brown	15.5	3.2	200	15.6
green	17.5	2.1	160	17.7
orange	18.7	1.0	100	19.0
red	19.8	0.7	60	20.0
yellow		groundwater		
blue		groundwater		

w.D. = with Daludar

MPB	O2	CO2	TPH	GT202 / O2	Temp.
clean	6.1	9.2	1340 w.D.	12.7 w.D.	22.2
black	8.5	7.0	600 w.D.	11.0 w.D	20.2
brown	12.1	4.8	720	12.1	18.4
green	17.6	1.8	160	17.6	16.6
orange	18.9	0.8	100	19.0	15.2
red	19.8	0.6	60	19.9	14.1
yellow		groundwater			13.2
blue		groundwater			12.5

Tab1

08/29/96

MPC	O2	CO2	TPH	GT202 / O2	Temp.
clean	18.5	2.2	160	18.5	—
black	18.5	1.8	140	18.6	18.7
brown	18.9	1.1	120	19.0	—
green	19.7	0.7	80	19.9	15.5
orange	20.2	0.3	40	20.5	—
red	20.5	0.1	20	20.7	13.4
yellow		groundwater			—
blue		groundwater			12.0

MPD	O2	CO2	TPH	GT202 / O2	Temp.
clean	20.1	0.8	20	20.3	19.9
black	20.3	0.7	0	20.5	—
brown	20.7	0.5	0	20.8	—
green	20.8	0.4	0	20.9	15.2
orange	20.8	0.4	0	20.9	—
red	20.8	0.5	0	20.9	12.9
yellow		groundwater			—
blue		groundwater			—

GP1	O2	CO2	TPH	GT202 / O2
white	16.7	3.9	240	16.8
blue	16.8	2.2	140	17.0
red	19.2	0.8	60	19.3
yellow	19.9	0.5	40	20.0

GP2	O2	CO2	TPH	GT202 / O2
white	18.9	2.0	120	19.0
blue	19.9	0.4	20	20.1
red	20.3	0.0	0	20.5
yellow		groundwater		

GP3	O2	CO2	TPH	GT202 / O2
white	20.0	0.6	40	20.2
blue	20.6	0.0	0	20.8
red	20.7	0.0	0	20.9
yellow		groundwater		

Tab1

08/29/96

GP4	O2	CO2	TPH	GT202 / O2
white	20.2	0.6	40	20.5
blue	20.9	0.0	0	20.9
red	20.9	0.0	20	20.9
yellow		groundwater		

GP5	O2	CO2	TPH	GT202 / O2
white	20.0	0.8	60	20.3
blue	20.9	0.0	0	20.9
red	20.9	0.0	0	20.9
yellow	20.9	0.0	0	20.9

GP8	O2	CO2	TPH	GT202 / O2
white	19.1	1.1	100	19.1
blue	20.3	0.1	20	20.2
red	20.5	0.0	20	20.4
yellow	20.5	0.0	20	20.5

08/30/96

Tab1

Calibration:

wheater: cloudy / raining

O2 gas	9.97 %		instrument	10.1 %
CO2 gas	10.02 %		instrument	10.0 %

Hexan gas	3983 ppm		instrument	3940 ppm

Messurement:

w.D. = with Deluder

Backgr.	O2	CO2	TPH	GT202 / O2	Temp.
clean	17.8 %	4.5 %	160 ppm	17.9 %	—
black	17.8	4.5	140	17.9	17.7 °C
brown	17.8	4.5	140	17.9	—
green	17.8	4.4	140	18.0	14.5
orange	17.8	4.4	140	18.0	—
red	17.8	4.4	140	18.0	12.8
yellow	17.8	4.4	120	18.1	—
blue		groundwater			11.9

MPA	O2	CO2	TPH	GT202 / O2
clean	8.2	8.1	260 w.D.	13.8 w.D
black	11.2	5.6	220	11.8
brown	14.1	4.0	200	14.4
green	16.2	2.9	180	16.6
orange	18.2	1.3	100	18.4
red	19.5	0.8	60	19.7
yellow		groundwater		
blue		groundwater		

MPB	O2	CO2	TPH	GT202 / O2	Temp.
clean	7.8	10.2	1220 w.D.	11.8 w.D.	21.9
black	5.7	8.2	580 w.D.	12.8 w.D	20.5
brown	9.5	5.9	460 w.D.	15.0 w.D.	18.7
green	16.1	2.2	220	16.7	16.8
orange	18.0	1.1	120	18.4	15.4
red	19.0	0.7	60	19.5	14.2
yellow		groundwater			13.3
blue		groundwater			12.7

Tab1 08/30/96

MPC	O2	CO2	TPH	GT202 / O2	Temp.
clean	18.4	2.2	140	18.4	—
black	18.1	1.9	120	18.3	18.8
brown	18.3	1.5	120	18.6	—
green	19.5	0.8	80	19.6	15.7
orange	20.1	0.5	40	20.4	—
red	20.5	0.3	20	20.5	13.4
yellow		groundwater			—
blue		groundwater			12.3

MPD	O2	CO2	TPH	GT202 / O2	Temp.
clean	20.0	0.8	60	20.2	11.0
black	20.2	0.7	40	20.4	—
brown	20.6	0.5	20	20.7	—
green	20.7	0.4	20	20.7	15.4
orange	20.8	0.4	20	20.8	—
red	20.8	0.6	20	20.8	12.8
yellow		groundwater			—
blue		groundwater			—

GP1	O2	CO2	TPH	GT202 / O2
white	16.7	3.7	200	17.4
• blue	15.5	3.1	160	16.3
red	18.5	0.9	60	19.3
yellow	19.5	0.6	20	20.2

GP2	O2	CO2	TPH	GT202 / O2
white	19.2	1.8	100	19.7
• blue	19.5	0.6	20	19.9
• red	20.2	0.1	0	20.6
yellow		groundwater		

GP3	O2	CO2	TPH	GT202 / O2
white	20.2	0.7	40	20.6
blue	20.9	0.0	0	20.9
• red	20.8	0.0	0	20.9
yellow		groundwater		

Tab1 08/30/96

GP4	O2	CO2	TPH	GT202 / O2
white	20.5	0.6	20	20.6
blue	20.9	0.0	0	20.9
red	20.9	0.0	0	20.9
yellow		groundwater		

GP5	O2	CO2	TPH	GT202 / O2
white	20.0	0.8	60	20.3
blue	20.9	0.0	0	20.9
red	20.9	0.0	0	20.9
yellow	20.9	0.1	0	20.9

GP8	O2	CO2	TPH	GT202 / O2
white	19.0	7.8	100	19.6
blue	20.1	0.4	0	20.7
red	20.5	0.1	0	20.9
yellow	20.7	0.1	0	20.9

NOVEMBER 1996 IN SITU RESPIRATION TEST RAW DATA

Date: 11-25-96 **Time:** 10:00

Tabelle1

Projekt: Rhein Main Air Base R 68.346

Date: 11/25/96 **Time:** 09:00

Weather: SNOW **Temperature:** - 2°C

Instrument calibration:

O2 gas:	9.97%		Instrument:	10.5	
CO2 gas:	10.02%		Instrument:	10.0	
Hexan gas:	3983ppm		Instrument:	4000	

Messurement:

MPA	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	19.4	2.3	120	19.4	
black	20.9	0.6	0	20.7	
brown	20.9	0.3	0	20.9	
green	20.9	0.1	0	20.9	
orange	20.9	0	0	20.9	
red	20.9	0	0	20.9	
yellow		ground water			
blue		ground water.			

MPB	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	18.0	4.3	480	17.6	8.7
black	18.7	2.8	240	18.9	12.3
brown	19.8	1.9	180	19.8	13.9
green	20.1	0.8	100	20.9	16.9
orange	20.9	0.7	0	20.9	15.0
red	20.9	0.6	0	20.9	14.9
yellow		ground water			14.5
blue		ground water			14.0

Tabelle1

Date: 11-25-96 **Time:** 10:00

MPC	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.2	1.5	100	20.2	
black	20.8	0.5	40	20.9	11.4
brown	20.9	0	0	20.9	
green	20.9	0	0	20.9	13.5
orange	20.9	0	0	20.9	
red	20.9	0	0	20.9	13.7
yellow		ground water			
blue		ground water			13.4

MPD	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.9	0.6	40	20.9	6.9
black	20.9	0.5	20	20.9	
brown	20.9	0.2	0	20.9	~~11.2~~
green	20.9	0.2	0	20.9	11.2
orange	20.9	0.2	0	20.9	
red	20.9	0.3	0	20.9	13.4
yellow	20.9	0.3	0	20.9	
blue		ground water			

Background	O_2	CO_2	TPH	GT202-O_2	temp°C
clean	18.1	4.0	240	17.8	
black	18.4	4.0	240	17.9	11.2
brown	18.2	4.5	260	18.2	
green	18.0	4.6	260	18.0	13.3
orange	18.0	4.8	280	18.1	
red	17.9	4.8	260	17.8	13.4
yellow	18.8	4.8	280	18.4	
blue		ground water			13.0

GP1	O_2	CO_2	TPH	GT202-O_2
white	20.0	1.3	160	20.2
blue	20.2	0.7	100	20.6
red	20.2	0.7	80	20.6
yellow	20.0	1.1	180	20.1

Date: 11-25-96 **Time:** 10:30

GP2	O_2	CO_2	TPH	GT202-O_2
white	20,8	0,7	0	20,9
blue	20,8	0,3	0	20,9
red	20,9	0	0	20,9
yellow	20,5	0	0	20,8

GP3	O_2	CO_2	TPH	GT202-O_2
white	20,9	0	0	20,9
blue	20,9	0	0	20,9
red	20,9	0	0	20,9
yellow	20,5	0	0	20,9

groundwater

GP4	O_2	CO_2	TPH	GT202-O_2
white	20,9	0	0	20,9
blue	20,9	0	0	20,9
red	20,9	0	0	20,9
yellow	20,9	0,1	0	20,9

GP5	O_2	CO_2	TPH	GT202-O_2
white	20,9	0,1	0	20,9
blue	20,9	0	0	20,9
red	20,9	0	0	20,9
yellow	20,9	0,1	0	20,9

GP8	O_2	CO_2	TPH	GT202-O_2
white	20,9	0,3	40	20,9
blue	20,9	0,2	20	20,9
red	20,8	0,1	20	20,9
yellow	20,8	0	20	20,9

Instruments after messurement

O_2	
CO_2	
TPH	

11-25-96

BLOWER OFF: 11:30

FOR RESPIRATION - TEST

Projekt: Rhein Main Air Base R 68.346

Date: 11-26-96 **Time:** 11:17

Weather: SUNNY **Temperature:** 4°C

Instrument calibration:

O2 gas:	9.97%	10.1	Instrument:	10.1	
CO2 gas:	10.02%	10.0	Instrument:	10.0	
Hexan gas:	3983ppm		Instrument:	3960	

Messurement:

MPA	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	18.0	3.0	160	18.6	
black	18.9	1.1	80	19.6	
brown	19.5	0.8	40	20.2	
green	19.8	0.7	20	20.5	
orange	20.0	0.7	0	20.4	
red	20.1	0.6	20	20.8	
yellow		ground water			
blue		ground water			

MPB	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	16.9	4.1	480	17.2	8.4
black	17.5	3.2	260	17.7	12.1
brown	18.1	2.4	180	18.7	14.0
green	19.7	1.1	100	20.3	14.8
orange	20.1	0.8	60	20.8	14.9
red	20.1	0.8	60	20.9	15.0
yellow		ground water			14.6
blue		ground water			14.4

Date: 11-26-96 **Time:** 12:00

MPC	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	19.8	1.6	100	20.6	
black	20.1	0.8	60	20.9	11.0
brown	20.8	0.5	20	20.9	
green	20.8	0.5	20	20.9	13.4
orange	20.9	0.3	0	21.0	
red	20.9	0.3	0	21.1	13.6
yellow		ground water			
blue		ground water			13.2

GT 202 O_2 new calibration 21.7 → 20.9% O_2

MPD	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.9	0.7	40	20.8	6.3
black	20.9	0.5	20	20.8	
brown	20.9	0.3	20	20.9	
green	20.9	0.3	20	20.9	13.0
orange	20.9	0.8	20	20.9	
red	20.9	0.5	20	20.9	13.4
yellow					
blue					

Background	O_2	CO_2	TPH	GT202-O_2	temp°C
clean	18.5	3.5	180	18.6	
black	18.1	3.5	180	18.1	11.1
brown	18.1	4.1	200	18.1	
green	18.6	4.2	200	18.6	13.4
orange	18.0	4.2	200	17.7	
red	17.9	4.2	200	17.8	13.6
yellow					
blue					13.1

GP5	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.5	20	20.9
blue	20.9	0.1	0	20.9
red	20.9	0.2	0	20.9
yellow	20.9	0.7	20	20.9

Date: 11-26-96 **Time:** 12:40

GP2	O_2	CO_2	TPH	GT202-O_2
white	20.0	0.9	80	20.6
blue	20.7	0.4	20	20.8
red	20.9	0.2	0	20.9
yellow	20.8	0.1	0	20.9

GP3	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.2	0	20.9
blue	20.9	0	0	20.9
red	20.9	0	0	20.9
yellow	ground water			

GP4	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.4	0	20.9
blue	20.9	0.2	0	20.9
red	20.9	0.1	0	20.9
yellow	20.9	0.3	0	20.9

GP 1	O_2	CO_2	TPH	GT202-O_2
white	19.5	2.0	120	19.8
blue	20.0	0.8	60	20.7
red	20.3	0.7	40	20.9
yellow	20	1.0	80	20.8

GP8	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.5	20	20.9
blue	20.9	0.3	0	20.9
red	20.9	0.4	0	20.9
yellow	20.9	0.5	0	20.9

Instruments after messurement

O_2	
CO_2	
TPH	

Projekt: Rhein Main Air Base R 68.346

Date: 11-27-96 **Time:** 13:30

Weather: raining **Temperature:** 1.5 °C

Instrument calibration:

O2 gas:	9.97%	-	Instrument:	10.1	
CO2 gas:	10.02%		Instrument:	10.0	
Hexan gas:	3983ppm		Instrument:	4000	

Messurement:

MPA	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	18.0	2.9	180	17.9	
black	18.8	1.5	100	18.6	
brown	19.2	1.0	80	19.2	
green	20.2	0.8	60	20.0	
orange	19.9	0.7	40	19.9	
red	20.2	0.7	20	20.5	
yellow		ground water			
blue		ground water			

MPB	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	16.0	4.5	380	16.0	8.2
black	16.2	3.9	160	16.2	12.0
brown	17.2	2.7	100	17.0	13.8
green	19.2	1.1	20	19.2	14.7
orange	20.2	0.7	0	20.1	15.2
red	20.0	0.7	0	20.2	14.9
yellow		ground water			
blue		ground water			

Date: 11-27-96 **Time:** 14:15

MPC	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.0	1.5	20	20.1	
black	20.1	0.8	0	20.4	11.0
brown	20.8	0.6	20	20.9	
green	20.9	0.5	0	20.9	14.0
orange	20.9	0.3	0	20.9	
red	20.9	0.2	0	20.9	14.4
yellow		ground water			
blue		groundwater			

MPD	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.9	0.7	60	20.9	3.9
black	20.9	0.6	40	20.9	
brown	20.9	0.5	40	20.9	
green	20.9	0.4	40	20.9	13.9
orange	20.9	0.4	40	20.9	
red	20.9	0.5	40	20.9	13.8
yellow		ground water			
blue		ground water			

Background	O_2	CO_2	TPH	GT202-O_2	temp°C
clean	18.2	3.6	180	18.1	
black	18.2	3.5	180	18.1	11.2
brown	18.1	4.0	180	18.0	
green	18.1	4.0	180	17.9	13.5
orange	18.1	4.0	180	17.8	
red	18.3	4.0	180	17.8	13.8
yellow		ground water			
blue		groundwater			13.3

GP1	O_2	CO_2	TPH	GT202-O_2
white	19.5	2.0	140	19.5
blue	20.2	0.8	60	20.2
red	20.3	0.7	40	20.6
yellow	20.2	0.8	80	20.5

Tabelle1

Date: 11-27-96 **Time:** 15:15

GP2	O_2	CO_2	TPH	GT202-O_2
white	20.3	0.9	80	20.6
blue	20.8	0.3	0	20.9
red	20.8	0.1	0	20.9
yellow	20.8	0.1	0	20.9

GP3	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.4	20	20.9
blue	20.9	0.1	0	20.9
red	20.9	0	0	20.9
yellow	—	—	—	—

groundwater

GP ~~#~~ 8	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.5	20	20.9
blue	20.8	0.2	0	20.8
red	20.9	0.2	0	20.9
yellow	20.9	0.4	20	20.9

GP5	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.4	20	20.9
blue	20.9	0	0	20.9
red	20.9	0	0	20.9
yellow	20.9	0.6	20	20.9

GP ~~#~~ 4	O_2	CO_2	TPH	GT202-O_2
white	20.9	0.1	0	20.9
blue	20.9	0	0	20.9
red	20.9	0	0	20.9
yellow	20.9	0	0	20.9

Instruments after messurement

O_2	
CO_2	
TPH	

Projekt: Rhein Main Air Base R 68.346

Date: 28.11.96 **Time:** 13^{30}

Weather: Snow **Temperature:** -1 C°

Instrument calibration:

O2 gas:	9.97%		Instrument:	9.9	
CO2 gas:	10.02%		Instrument:	10.90	
Hexan gas:	3983ppm		Instrument:	4000	

Messurement:

MPA	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	18,0	3,1	200	16,8	
black	18,5	2,0	120	17,2	
brown	19.0	1,3	100	18,6	
green	19,5	1,1	100	18,9	
orange	19,5	1.0	80	18,9	
red	20,2	0,7	60	19,8	
yellow					
blue					

MPB	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	16,9	4,2	500	15,5	8,0
black	16,6	4,0	280	15,3	12,0
brown	17,0	3,1	220	16,2	13,7
green	18,9	1,4	140	18,2	14,7
orange	19,5	0,8	100	18,3	14,9
red	19,8	0,8	80	19,8	14,8
yellow					
blue					

Tabelle1

Date: 28.11.96 **Time:** 14 25

MPC	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.0	1,5	20	20.9	
black	20.0	0,9	0	20.9	10.5
brown	20.0	0.7	0	20.9	13,4
green	20.0	0,5	0	20.9	
orange	20.6	0.2	0	20.8	~~13.6~~
red	20.8	0,2	0	20,7	13,5
yellow					
blue					

MPD	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20.8	0.7	0	20.7	2,5
black	20.8	0.5	0	20.7	
brown	20.9	0.4	0	20.8	
green	20.9	0,4	0	20.9	12,9
orange	20.9	0.4	0	20.8	
red	20.9	0.4	0	20.8	13,3
yellow					
blue					

Background	O_2	CO_2	TPH	GT202-O_2	temp°C
clean	18,5	3,4	180	17,7	
black	18,5	3,4	180	17,5	10,8
brown	18,5	3,9	200	17,5	
green	18,2	3,9	200	17,5	13,2
orange	18,4	3,8	200	17,5	
red	18,5	3,9	200	17,3	13,5
yellow	18,5	3,9	200	17,3	
blue					

GP1	O_2	CO_2	TPH	GT202-O_2
white	19,5	2,0	160	19,4
blue	19,6	0,8	100	19,3
red	20,0	0,7	60	19,9
yellow	20,0	0,7	80	19,9

Tabelle1

Date: 28.11.96 **Time:** 15^{15}

GP2	O_2	CO_2	TPH	GT202-O_2
white	20,8	0,8	100	20,7
blue	20,8	0,1	20	20,7
red	20,8	0	0	20,7
yellow	20,8	0	0	20,7

GP3	O_2	CO_2	TPH	GT202-O_2
white	20,8	0,3	20	20,9
blue	20,9	0	0	20,9
red	20,9	0	0	20,9
yellow				

GP4	O_2	CO_2	TPH	GT202-O_2
white	20,8	0,2	0	20,9
blue	20,9	0,1	0	20,9
red	20,9	0	0	20,9
yellow	20,9	0,2	0	20,9

GP5	O_2	CO_2	TPH	GT202-O_2
white	20,9	0,3	20	20,9
blue	20,9	0,1	0	20,9
red	20,9	0,1	0	20,9
yellow	20,9	0,5	20	20,9

GP8	O_2	CO_2	TPH	GT202-O_2
white	20,8	0,6	40	20,9
blue	20,8	0,1	0	20,8
red	20,8	0,2	0	20,8
yellow	20,8	0,4	20	20,8

Instruments after messurement

O_2	
CO_2	
TPH	

Projekt: Rhein Main Air Base R 68.346

Date: 29.11.96 **Time:** 12³⁰

Weather: Snow **Temperature:** 1+ °C

Instrument calibration:

O2 gas:	9.97%		Instrument:	9,9	
CO2 gas:	10.02%		Instrument:	10,1	
Hexan gas:	3983ppm		Instrument:	4000	

Messurement:

MPA	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	18,5	3,2	140	17,0	
black	19,5	1,8	40	18,2	
brown	18,5	1,9	180	17,9	
green	13,0	1,5	160	18,7	
orange	20,1	0,8	160	20,2	
red	19,3	1,0	120	19,8	
yellow					
blue					

MPB	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	15,6	4,2	580	13,9	7,6
black	16,0	3,3	300	13,9	11,7
brown	16,6	3,2	200	14,8	13,5
green	18,1	1,6	100	17,4	14,6
orange	19,0	1,0	40	18,4	14,9
red	19,2	0,8	40	19,0	14,9
yellow					
blue					

Date: 29.11.96 **Time:** 13^{15}

MPC	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	19,8	1,2	160	19,7	
black	19,9	0,9	140	19,7	20,3
brown	19,9	0,7	100	19,8	
green	20,2	0,5	60	20,3	13,2
orange	20,5	0,7	40	20,2	
red	20,6	0,2	20	20,7	13,6
yellow					
blue					

MPD	O_2	CO_2	TPH	GT202-O_2	temp °C
clean	20,6	0,6	80	20,8	6,5
black	20,5	0,5	60	20,8	
brown	10,6	0,2	40	20,8	
green	20,8	0,2	40	20,8	12,8
orange	20,6	0,1	40	20,8	
red	20,6	0,4	40	20,7	13,3
yellow					
blue					

Background	O_2	CO_2	TPH	GT202-O_2	temp°C
clean					
black					
brown					
green					
orange					
red					
yellow					
blue					

GP1	O_2	CO_2	TPH	GT202-O_2
white	19,6	2,1	230	19,4
blue	19,4	1,0	160	19,0
red	20,0	0,7	100	19,8
yellow	20,0	0,7	100	19,7

Date: 29.11.96 **Time:** 14[15]

GP2	O_2	CO_2	TPH	GT202-O_2
white	20,2	0,8	140	20,4
blue	20,4	0,2	20	20,5
red	20,4	0,1	20	20,5
yellow	20,4	0,2	20	20,5

GP3	O_2	CO_2	TPH	GT202-O_2
white	20,8	0,4	40	20,9
blue	20,8	0,1	0	20,9
red	20,9	0	0	20,9
yellow	20,8	0,1	0	20,8

GP4	O_2	CO_2	TPH	GT202-O_2
white	20,5	0	0	20,9
blue	20,4	0	0	20,9
red	20,8	0	0	20,7
yellow	20,8	0	20	20,7

GP5	O_2	CO_2	TPH	GT202-O_2
white	20,9	0	0	20,9
blue				
red				
yellow				

GP8	O_2	CO_2	TPH	GT202-O_2
white				
blue				
red				
yellow				

Instruments after messurement

O_2	
CO_2	
TPH	

AUGUST 1998 IN SITU RESPIRATION TEST RAW DATA

Project: Rhein-Main Air Base

Respiration Test August 1998

	24.08.					25.08.					26.08.					27.08.					28.08.			
MPA	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPA	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPA	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPA	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPA	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)
clean	20	2.2			clean	20.2	0.7			clean	18.5	1.8			clean	20	0.8		200	clean	20.1	0.9		140
black	20.2	1.5			black	18.7	2.5			black	17.1	3.8			black	16.8	4.2		320	black	17	4.2		250
brown	20.8	0.9			brown	19.7	1.2			brown	18.3	2.2			brown	18	2.5		280	brown	18.5	2.8		220
green	21	0.7			green	20	0.8			green	18.3	1.5			green	19.1	1.8		250	green	19.5	1.7		180
orang	21	0.1			orang	20.5	0.5			orang	19.8	0.7			orang	19.8	0.7		210	orang	20.1	0.8		140
red	21	0.6			red	20.3	0.8			red	20	0.9			red	19.8	0.9		220	red	20.2	0.8		150
yello	water				yello	water				yello	water				yello	water				yello	water			
blue					blue					blue					blue					blue				

	24.08.					25.08.					26.08.					27.08.					28.08.			
MPB	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPB	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPB	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPB	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPB	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)
clean	20	12	20.5		clean	19.8	11.2	20.7		clean	20	1.8	20.9		clean	18	11.5	20.9	280	clean	18.5	3.2	20.8	310
black	16.5	6	19.8		black	14.5	8.5	19.6		black	11	8.8	19.6		black	10	8.8	19.7	360	black	10.3	8.5	19.9	290
brown	20	1.8	17.8		brown	18.4	4.1	17.7		brown	16	3.8	17.7		brown	15	4.4	17.8	330	brown	15	4.7	18.4	270
green	21	0.5	16.2		green	19.2	0.8	16		green	19.5	0.7	15.7		green	19.3	0.7	16.2	220	green	19.5	0.9	16.4	170
orang	21	0.5	14.5		orang	20	0.7	14.4		orang	20	0.6	14.3		orang	20	0.6	14.6	200	orang	20.6	0.7	14.7	140
red	21	0.6	13.9		red	20	0.7	13.6		red	20	0.7	13.4		red	20	0.7	13.9	200	red	20.6	0.7	14.1	145
yello	water		12.9		yello	water		12.8		yello	water		12.8		yello	water		12.9		yello	water		13.4	
blue			11.7		blue			11.6		blue			11.6		blue			11.8		blue			12	

	24.08.					25.08.					26.08.					27.08.					28.08.			
MPC	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPC	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPC	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPC	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPC	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)
clean	16.8	8.9			clean	16	8.3			clean	10.1	8.5		340	clean	10.3	8		340	clean	14.5	6.8		260
black	10	8.5	19.4		black	9	8.5			black	10	8.7	19.2	340	black	10.2	8.1	19.4	340	black	12.5	7	19.3	270
brown	12	8			brown	11.3	8			brown	10.4	8		360	brown	12	7.8		360	brown	13.9	7		280
green	14.9	7.8	15.5		green	14.2	7.7			green	13.8	7.5	15.5	420	green	13.2	7.2	15.4	420	green	15.4	6.1	15.7	330
orang	17	7			orang	15.5	7			orang	15.1	7		490	orang	15	6.9		490	orang	16.5	5.9		380
red	17.5	7	13.4		red	16.8	7			red	16.1	6.9	13.4	400	red	15.9	6.7	13.6	400	red	17.3	5.1	13.6	310
yello	water				yello	water				yello	water				yello	water				yello	water			
blue			12.5		blue					blue			12.2		blue			12.6		blue			12.6	

Project: Rhein-Main Air Base

Respiration Test August 1998

	24.08.					25.08.					26.08.					27.08.					28.08.			
MPD	O2 (%)	O2 (%)C	Temp (C)	TPH (ppm)	MPD	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPD	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPD	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	MPD	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)
clean	16	5.5	19.1		clean	15.1	5	19.5		clean	15	5.7	19.6		clean	15.8	5.1	19.3	310	clean	17.2	4.5	19	270
black	14.2	6.9			black	14.9	6.3			black	13.8	6.9			black	14	6.3		320	black	15.9	5.2		280
brown	11.3	8.8			brown	11	8.2			brown	10.8	9			brown	11.1	8.2		330	brown	13.4	6		290
green	10	9.8	15.8		green	10	9.3	15.9		green	9.3	10.1	15.8		green	9.8	9.2	15.9	340	green	12	7.6	15.9	290
orang	8.9	10.8			orang	8	10.1			orang	8	11			orang	8.2	10.2		340	orang	11	8.3		300
red	8.5	11	13.3		red	8	10.5	13.2		red	8	11.8	13.1		red	8	10.3	13.3	330	red	11	8.1	13.4	300
yello	water				yellow					yello	water				yello	water				yellow				
blue					blue					blue					blue					blue				

	24.08.					25.08.					26.08.					27.08.					28.08.			
Back-grd	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	Back-grd	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	Back-grd	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	Back-grd	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)	Back-grd	O2 (%)	CO2 (%)	Temp (C)	TPH (ppm)
clean	18.2	4			clean	18	4.2	18.2		clean	17.5	4.8	19.2		clean	17.5	4.5		180	clean	18.2	3.9		180
black	17.7	4	18.7		black	17	4.4			black	17.4	4.8			black	17.5	4.4	18.8	180	black	17.6	3.9	18.8	170
brown	18	4.1			brown	17.9	4.2			brown	17.5	4.8			brown	17.5	4.4		180	brown	18.2	3.9		170
green	18.6	4	15.2		green	18.3	4.1	15.1		green	17.6	4.7	15.6		green	17.4	4.4	15.2	180	green	18.5	3.8	15.2	170
orang	18.4	4			orang	18.1	4.1			orang	17.6	4.7			orang	17.5	4.4		180	orang	18.3	3.8		170
red	18.3	3.8	13.6		red	18	4	13.3		red	17.6	4.6	14.2		red	17.5	4.4	13.6	180	red	18.3	3.6	13.5	170
yello	18.5	3.7			yello	18.1	4			yello	17.6	4.6			yello	water				yello	18.4	3.6		170
blue			12.6		blue			12.2		blue	water				blue					blue	wate		12.6	

	24.08.				25.08.				26.08.				27.08.				28.08.	
GP1	O2 (%)	CO2 (%)	TPH (ppm)	GP1	O2 (%)	CO2 (%)	TPH (ppm)	GP1	O2 (%)	CO2 (%)	TPH (ppm)	GP1	O2 (%)	CO2 (%)	TPH (ppm)	GP1	O2 (%)	CO2 (%)	TPH (ppm)
white	13.1	9.5		white	12.6	9.5		white	14	9		white	15.1	7.1	330	white	16.9	5.1	200
blue	19.8	3.8		blue	16.8	4.9		blue	16.3	5.7		blue	15.8	6	330	blue	17	4.8	220
red	20.5	0.8		red	19.7	0.8		red	19.9	0.8		red	19.8	0.8	210	red	20.1	0.8	100
yello	20.5	0.8		yello	19	0.8		yello	20	0.8		yello	20	0.6	190	yello	20.6	0.6	80

Project: Rhein-Main Air Base

Respiration Test August 1998

	24.08.				25.08.				26.08.				27.08.				28.08.		
	O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH
GP2	(%)	(%)	(ppm)	GP2	(%)	(%)	(ppm)	GP2	(%)	(%)	(ppm)	GP2	(%)	(%)	(ppm)	GP2	(%)	(%)	(ppm)
white	20	2.2		white	13.1	8		white	14	7.3		white	16	5.5	330	white	18	4	180
blue	13.8	9.3		blue	12.7	9.3		blue	12.2	10		blue	12.3	9.3	350	blue	15	6.9	210
red	19.3	2.5		red	18	2.8		red	18.1	3.8		red	18	3.8	310	red	18.5	3.3	180
yello	20	2.5		yello	water			yello	19	3		yello	19	2.8	260	yello	19.9	1.9	150

	24.08.				25.08.				26.08.				27.08.				28.08.		
	O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH
GP3	(%)	(%)	(ppm)	GP3	(%)	(%)	(ppm)	GP3	(%)	(%)	(ppm)	GP3	(%)	(%)	(ppm)	GP3	(%)	(%)	(ppm)
white	12	6.5		white	15.2	4.2		white	15	5.2		white	16.5	4.2	305	white	18	3.1	180
blue	10.7	10		blue	11	9.2		blue	11.5	9.8		blue	12	8.6	380	blue	15	6.2	240
red	12.3	6.8		red	16.8	6.8		red	16.4	7		red	16	6.5	470	red	17.5	5	310
yello	water			yello	water			yello	water			yello	water			yello	water		

	24.08.				25.08.				26.08.				27.08.				28.08.		
	CO2	O2	TPH		CO2	O2	TPH		CO2	O2	TPH		CO2	O2	TPH		CO2	O2	TPH
GP4	(%)	(%)	(ppm)	GP4	(%)	(%)	(ppm)	GP4	(%)	(%)	(ppm)	GP4	(%)	(%)	(ppm)	GP4	(%)	(%)	(ppm)
white	19	2.3		white	18.7	1.9		white	18.9	2.2		white	19	2	250	white	19.8	1.5	110
blue	12.9	6.7		blue	12.2	6.2		blue	12.8	6.9		blue	13.2	6.4	365	blue	15.9	5	240
red	13.3	9		red	13	8.2		red	13.7	8.8		red	14	7.8	580	red	16.1	6	400
yello	13.1	8.8		yello	13.8	8.2		yello	14.1	8.9		yello	14.5	8	480	yello	17	5.2	290

	24.08.				25.08.				26.08.				27.08.				28.08.		
	O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH		O2	CO2	TPH
GP5	(%)	(%)	(ppm)	GP5	(%)	(%)	(ppm)	GP5	(%)	(%)	(ppm)	GP5	(%)	(%)	(ppm)	GP5	(%)	(%)	(ppm)
white	20	1.8		white	19.8	1.4		white	19.1	1.9		white	20	1.8	220	white	20.5	1	180
blue	15.8	4.2		blue	15.1	4.1		blue	15	4.4		blue	15.4	4.2	295	blue	17.2	3.4	180
red	12.5	6.9		red	12.5	6.6		red	14	7		red	13.8	6.6	380	red	16	4.7	270
yello	11.2	7.9		yello	11.2	7.8		yello	12.2	7.2		yello	12.9	7.3	500	yello	15.9	5.1	360

Project: Rhein-Main Air Base

Respiration Test August 1998

	24.08.				25.08.				26.08.				27.08.				28.08.	
	O_2	CO_2	TPH		O_2	CO_2	TPH		O_2	CO_2	TPH		O_2	CO_2	TPH		O_2	CO_2	TPH
GP8	(%)	(%)	(ppm)	GP8	(%)	(%)	(ppm)	GP8	(%)	(%)	(ppm)	GP8	(%)	(%)	(ppm)	GP8	(%)	(%)	(ppm)
white	18	4		white	18	3.2		white	17	3.8		white	17.8	3.5	290	white	18.8	2.9	160
blue	19	2		blue	19	2		blue	18.8	2.2		blue	18.8	2.5	260	blue	19.5	2	150
red	20	1		red	20	0.9		red	19.8	1		red	20	0.8	240	red	20.2	0.8	120
yello	21	1		yello	20	0.9		yello	20	0.9		yello	20	0.8	220	yello	20.5	0.7	100

APPENDIX G

RESULTS FROM GROUNDWATER QUALITY SAMPLING

OCTOBER 1996

FALL 1996 YSI PROBE-HEAD WATER QUALITY DATA

SAMPLE	SAMPLING DATE	TIME (hrs)	DEPTH (m)	TEMP (c)	COND (mV/cm)	DO (%)	DO (mg/l)	ORP (mV)	pH
NW2	10/2/96	1650	7	14.7	0.492	15.7	1.47	53	6.3
GP5	10/8/96	800	9	13.6	0.297	13.5	1.4	-55	6.11
GP2	10/7/96	1115	8	14.8	0.37	14.6	2.15	-201	6.25
GP9	10/8/96	1300	8.5	16.9	0.269	20	1.9	-110	5.39
GP4	10/8/96	1035	2.0*	15.9	0.576	32	3.01	-123	5.5
GP10	10/10/96	800	10	13.7	0.24	nr	0.29	-345	6.64
GP3@9M	10/10/96	1345	9	13.3	0.38	12	1.12	-206	6.33
GP1@9M	10/11/96	800	9	12.8	0.363	nr	4.47	-90	5.85
GP1@10M	10/11/96	900	10	12.3	0.279	18.2	1.82	-132	5.56
GP3@11M	10/11/96	1100	11	12.5	0.336	2.8	0.2	-269	6.5
GP9C	10/11/96	1300	10	13.2	0.312	nr	0.29	-336	5.82
GP9B	10/14/96	800	10	13.7	0.295	8.4	0.86	-104	6.03
GP8	10/14/96	1025	10.5	15.1	0.455	3.4	0.34	70	6.13
GP16	10/14/96	1305	10	15.8	0.428	2	0.2	-131	6.39
GP9A	10/15/96	800	10	11.9	0.328	7.2	0.74	-48	6.3
GP10A	10/15/96	1420	10	14.6	0.58	7.3	0.74	30	5.98
GP18	10/15/96	1510	10	13.7	0.315	3.3	0.33	-94	6.62

nr = not recorded

* depth measured from base of sand pit

file: c:\RM'96-ysi-data

WATER QUALITY DATA
RHEIN MAIN AIR FORCE BASE

SAMPLE	SAMPLING DATE	TIME	ANALYSIS DATE	TIME	SULFIDE mg/L	MN mg/L	IRON +2 mg/L	NITRATE mg/L	SULFATE mg/L
NW2	10/2/96	15:00	10/2/96	15:30	NA	1.4	0.02	3.30	HIGH
GP5	10/8/96	NA	10/8/96	NA	0.117	3.1	2.17	2.70	52.1*
GP2	10/7/96	15:40	10/8/96	10:00	NA	NA	NA	3.70	LOW
GP9	10/8/96	13:45	10/8/96	15:00	0.105	3.9	2.4	4.10	59.8*
GP4	10/8/96	15:40	10/8/96	16:00	0.155	2.3	1.93	10.60	HIGH
GP10	10/10/96	15:10	10/10/96	13:10	0.09	4.0	5.1**	1.00	1.4
GP3 @ 9M	10/10/96	14:00	10/10/96	15:15	0.041	1.2	1.96	6.30	0.94
GP1 @ 10M	10/11/96	8:50	10/11/96	10:00	0.049	0.5	1.01	15.20	63.3
GP1 @ 9M	10/11/96	10:40	10/11/96	11:30	0.153	2.5	3.27	15.00	135.7
GP3 @ 11M	10/11/96	14:00	10/11/96	14:50	0.091	3.6	5.1**	1.10	1.33
GP9C	10/11/96	15:45	10/14/96	10:45	NA	0.8	4.84	16.70	100
GP9B	10/14/96	12:55	10/14/96	13:30	0.074	1.3	4.27	8.10	128
GP8	10/14/96	14:40	10/14/96	15:05	0.018	0.4	1.85	18.80	23.8
GP16	10/14/96	16:05	10/14/96	17:30	0.078	3.1	22.1	1.50	1.68
GP9A	10/15/96	10:40	10/15/96	11:05	0.087	0.8	38.8	1.90	53.5
GP10A	10/15/96	16:30	10/16/96	9:30	NA	NA	7.7	15.00	165.57
GP18	10/15/96	17:30	10/16/96	9:30	NA	NA	5.2	2.40	5.45

NA = not available
* Analyzed on 10/10 at 9:45
** Minimum value for iron. Actual value is greater.

Based on the development of turbidity in sample...
HIGH = above 50 mg/L
LOW = below 10 mg/L

OTHER REMARKS:
Often needed to dilute sample in order to fall within calibration limits set for sulfate in the colorimeter module.
Several times dilution of sample was necessary in order to fall within limits set for iron in the colorimeter module.

Analysis using Hach Kits takes appx one hour and was almost always done in the above order.
(Begining with sulfide and ending with sulfate)

BTEX CONCENTRATIONS
RHEIN MAIN AFB

SAMPLE	SAMPLING DATE	ANALYSIS DATE	BENZENE ppb	TOULENE ppb	ETHYLBENZENE ppb	M+P-XYLENE ppb	O-XYLENE ppb
GW3/95	9/30/96	10/3/96	159.61	25.37	503.39	521.75	0
NW2	10/2/96	10/3/96	3.31	0	0.28	0	0
GP2	10/7/96	10/8/96	4.02	1.09	29.94	21.81	0
GP5	10/8/96	10/8/96	4.51	0	0.89	0	0
GP9	10/8/96	10/8/96	0.18	0	0	0	0
GP4	10/8/96	10/8/96	0.19	0	0.27	0	0.07
GPD*	10/9/96	10/10/96	11144.76	9988.04	267	265.95	340.03
GP10	10/10/96	10/10/96	0	0	0	0	0
GP3 @ 9M	10/10/96	10/10/96	27.27	0	0	0	0
GP1 @ 10M	10/11/96	10/11/96	4.72	0	0	0	0
GP1 @ 9M	10/11/96	10/11/96	0	0	0	0	0
GP3 @ 11M	10/11/96	10/11/96	382.86	5.21	432.38	328.76	0
GP9C	10/11/96	10/14/96	0	0	0	0	0
GP9B	10/14/96	10/14/96	0.32	1.32	0	0	0.21
GP8	10/14/96	10/14/96	30.09	1	0	0	0
GP16	10/14/96	10/14/96	2.05	1.47	0	0	0
GP9A	10/15/96	10/15/96	0.193	0.686	0	0	0
GP10A	10/15/96	10/16/96	7.225	0	0	0	0
GP18	10/15/96	10/16/96	0.545	0	0	0	0

*GPD was driven and sampled at a location in the fuel yard during the site visit by the International group on 10/9/96

SEPTEMBER/OCTOBER 1998

Contaminant Concentrations
September/October 1998
POL Yard, Rhein Main AB

Sample ID	TPH-P (mg/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	m,p-Xylene (ug/L)	o-Xylene (ug/L)	TPH-E (mg/L) (Jet Fuel)	TPH-E (mg/L) (Diesel)	TPH-E (mg/L) (Oil)
GP-1	2	3.1	ND	2	9.9	1.9	NA	NA	NA
GP-1-10M	1.5	9.3	ND	5.8	13	1.7	NA	NA	NA
GP-1-14M	12	1400	78	870	1500	520	NA	NA	NA
GP-1-17M	0.076	ND	ND	ND	ND	ND	NA	NA	NA
GP-2	9.8	240	11	650	2300	48	NA	NA	NA
GP-3	6.8	450	ND	390	1200	6.7	NA	NA	NA
GP-3-10M	6.6	330	1.0	340	880	5.8	NA	NA	NA
GP-3-14M	0.068	0.56	ND	ND	ND	ND	NA	NA	NA
GP3-17M	0.085	ND	ND	ND	0.5	ND	NA	NA	NA
GP-4	0.6	40	ND	ND	ND	ND	NA	NA	NA
GP-5	3.2	12	1.4	260	280	5.1	NA	NA	NA
GP5-14M	7	99	5.2	270	1700	61	NA	NA	NA
GP-6	0.13	ND	ND	ND	ND	ND	NA	NA	NA
GP-7	0.14	ND	ND	ND	ND	ND	NA	NA	NA
GP-8	ND	7.1	ND	ND	ND	ND	NA	NA	NA
GP-9	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-9B	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-9C	0.18	ND	ND	ND	ND	ND	NA	NA	NA
GP-10	0.15	76	ND	ND	ND	ND	NA	NA	NA
GP-10A	5.9	780	77	310	170	48	NA	NA	NA
GP-11	0.14	0.61	ND	ND	ND	ND	NA	NA	NA
GP-12	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-14	0.56	8.3	ND	2.4	1	1.2	NA	NA	NA
GP-15	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-16	0.14	6.5	ND	4.4	1.9	1.8	NA	NA	NA
GP-17	ND	1.6	ND	0.78	ND	ND	NA	NA	NA
GP-18	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-19	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-20	0.074	ND	ND	ND	ND	ND	NA	NA	NA
GP-21	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-23	ND	ND	ND	ND	ND	ND	NA	NA	NA
GP-25	ND	ND	ND	ND	ND	ND	NA	NA	NA
MW-1	12	800	ND	390	1100	690	ND	ND	ND
MW-2	57	20,000	14,000	750	2000	800	ND	ND	ND
MW-3	18	4600	3300	510	1500	420	ND	150	ND

ND = Not detected
NA = Not analyzed

Natural Attenuation Parameters
September/October 1998
POL Yard, Rhein Main AB

Sample ID	Sulfide (mg/L)	Mn (mg/L)	Iron (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	Alkalinity (mg/L)
GP-1	0.063	0.8	1.29	8.9	61.84	10
GP-1-10M	0.125	2.1	2.61	5.6	51.68	60
GP-1-14M	0.215	7.5	2.28	2.6	58.9	180
GP-1-17M	0.165	1.3	1.42	9.7	66.89	25
GP-2	0.326	8.5	2.87	4.5	10.28	260
GP-3	0.055	6.7	2.13	5.1	1.87	160
GP-3-10M	0.245	5.9	2.54	3.2	8.29	180
GP-3-14M	0.096	0.14	1.56	4.4	62.92	60
GP3-17M	0.189	3.3	3.38	3	55.24	75
GP-4	0.086	1.0	0.75	0.25	15.01	70
GP-5	0.086	3.7	2.41	3.3	2.81	180
GP5-14M	0.166	3.8	2.31	2.7	1.98	160
GP-6	0.119	3.7	3.24	6.0	84.22	140
GP-7	0.165	3.5	2.25	3.2	19.69	200
GP-8	0.144	0.18	2.22	16.1	46.57	95
GP-9	0.121	0.5	3.82	4.2	74.25	50
GP-9B	0.065	1.3	2.82	5.4	27.16	25
GP-9C	0.074	0.15	2.91	2.6	24.72	120
GP-10	0.233	4.8	2.97	7.5	45.9	180
GP-10A	0.071	2.5	3.07	2.1	1.2	140
GP-11	0.047	2.9	3.25	4.4	59.72	55
GP-12	0.09	1.1	1.15	7.1	29.8	35
GP-14	1.086	2.2	5.09	4.8	6.6	120
GP-15	1.0	2.2	3.16	3.0	44.86	160
GP-16	0.074	3.0	2.89	2.7	18.95	195
GP-17	0.148	2.2	3.23	0.9	1.04	200
GP-18	0.08	1.5	2.36	1.7	2.73	180
GP-19	0.017	0.6	0.68	9.4	27.47	30
GP-20	0.067	3.2	1.69	21.1	42.25	45
GP-21	0.111	10.2	2.84	0.9	2.21	300
GP-23	0.04	0.6	0.74	5.8	73.45	50
GP-25	0.102	1.7	2.03	13.8	58.24	25
MW-1	0.04	4.7	0.87	1.3	42.17	90
MW-2	0.719	3.1	2.31	5	2.54	90
MW-3	1.87	3.5	1.61	6.6	0.81	85

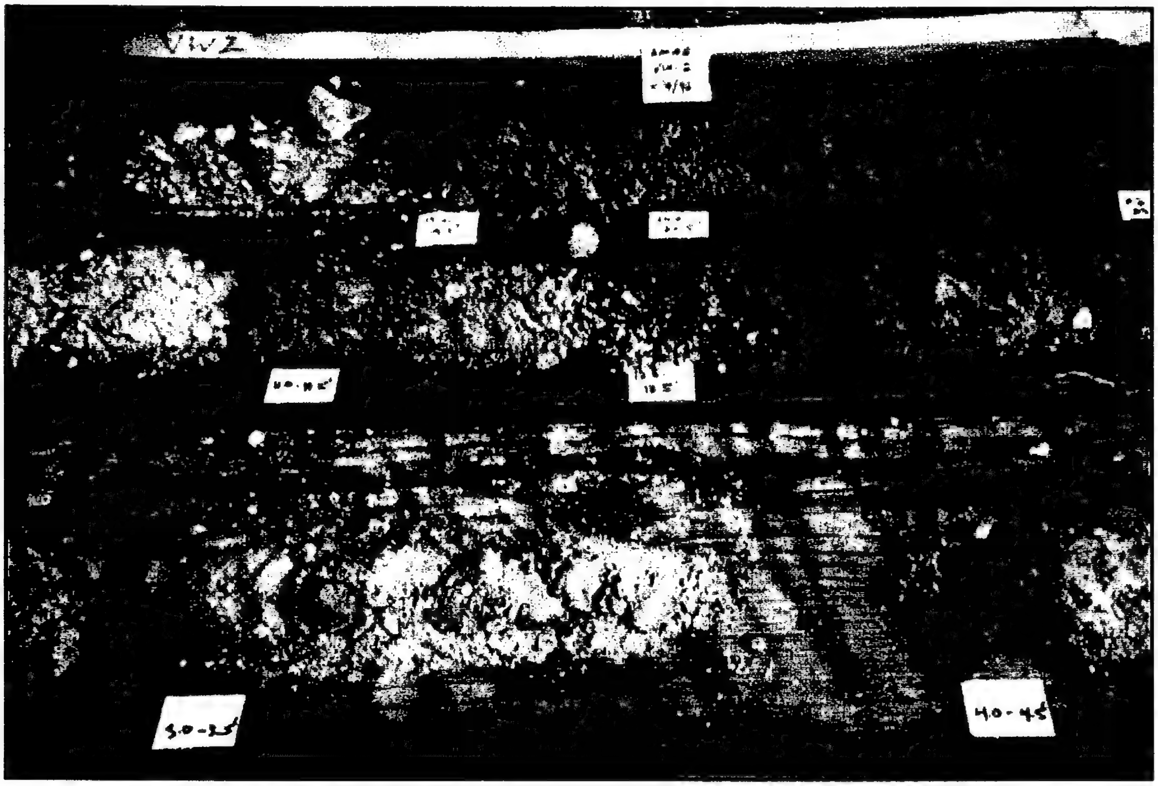
Probe Head Groundwater Quality Parameters Measured with YSI Instruments
Rhein-Main Air Base
1998 Survey

Well	Temp	Cond	Doc	DO	ORP	SpC	pH	Trb	Date
GP1	13.22	0.172	63.5	0.37	61.1	0.222	5.20	1.3	22-Sep
GP1 (10m)	13.33	0.187	59.4	0.45	-41.8	0.241	5.48	0.5	30-Sep
GP1 (14m)	12.59	0.362	77.8	0.61	-103.0	0.474	8.16	0.3	1-Oct
GP1 (17m)	14.34	0.369	68.6	1.12	-47.5	0.463	6.10	0.8	1-Oct
GP10	16.87	0.506	70.6	1.12	-9.4	0.600	6.18	-9.0	23-Sep
GP10A	12.68	0.220	64.5	0.36	-4.3	0.287	6.27	0.7	23-Sep
GP11	14.01	0.245	62.5	0.35	-4.2	0.310	6.24	0.8	29-Sep
GP12	13.57	0.194	78.8	4.55	88.8	0.248	5.82	0.7	29-Sep
GP14	13.56	0.295	67.6	0.39	-138.0	0.378	5.88	0.5	23-Sep
GP15	12.40	0.504	61.4	0.57	-109.6	0.664	6.28	0.0	25-Sep
GP17	13.35	0.311	56.3	0.32	-21.2	0.400	6.35	0.5	28-Sep
GP18	12.79	0.263	54.3	0.18	-30.3	0.344	6.64	0.4	28-Sep
GP19	14.35	0.165	76.8	8.57	78.2	0.207	6.04	0.8	29-Sep
GP2	13.28	0.350	63.5	0.74	-90.9	0.451	6.15	-0.3	24-Sep
GP20	12.68	0.326	55.3	0.62	50.7	0.426	5.79	0.4	28-Sep
GP21	13.88	0.439	56.3	0.28	-34.1	0.557	6.56	0.4	28-Sep
GP23	11.63	0.343	78.8	2.58	43.4	0.461	6.79	0.6	30-Sep
GP25	13.27	0.239	79.8	8.22	100.9	0.309	5.66	0.8	30-Sep
GP3	15.25	0.412	68.6	0.65	-38.5	0.507	6.10	1.3	22-Sep
GP3 (14m)	12.87	0.222	59.4	0.45	36.7	0.355	6.13	0.3	1-Oct
GP3 (16m)	12.84	0.274	69.6	0.54	10.8	0.357	6.24	-0.1	1-Oct
GP4	13.84	0.258	60.4	0.79	92.0	0.328	5.73	-0.5	24-Sep
GP5	13.29	0.278	63.5	0.59	-60.5	0.358	6.02	1.3	22-Sep
GP5 (14m)	12.81	0.268	90.0	20.80	-104.9	0.350	7.07	0.1	1-Oct
GP6	14.82	0.359	59.4	0.71	-42.3	0.445	6.12	-3.0	24-Sep
GP7	12.22	0.340	64.5	0.44	17.2	0.449	5.32	0.7	30-Sep
GP8	12.74	0.374	59.4	0.63	31.8	0.489	5.86	-0.2	25-Sep
GP9	13.17	0.261	64.5	0.54	-53.0	0.337	5.80	0.5	23-Sep
GP9B	13.08	0.199	61.4	0.58	58.8	0.250	5.64	-0.2	25-Sep
GP9C	13.69	0.233	66.5	0.57	-13.7	0.298	6.19	0.2	24-Sep
GP16	12.40	0.504	61.4	0.57	-109.6	0.664	6.28	0.0	25-Sep
MW3	14.30	0.164	59.4	0.28	-107.9	0.205	8.26	0.1	2-Oct

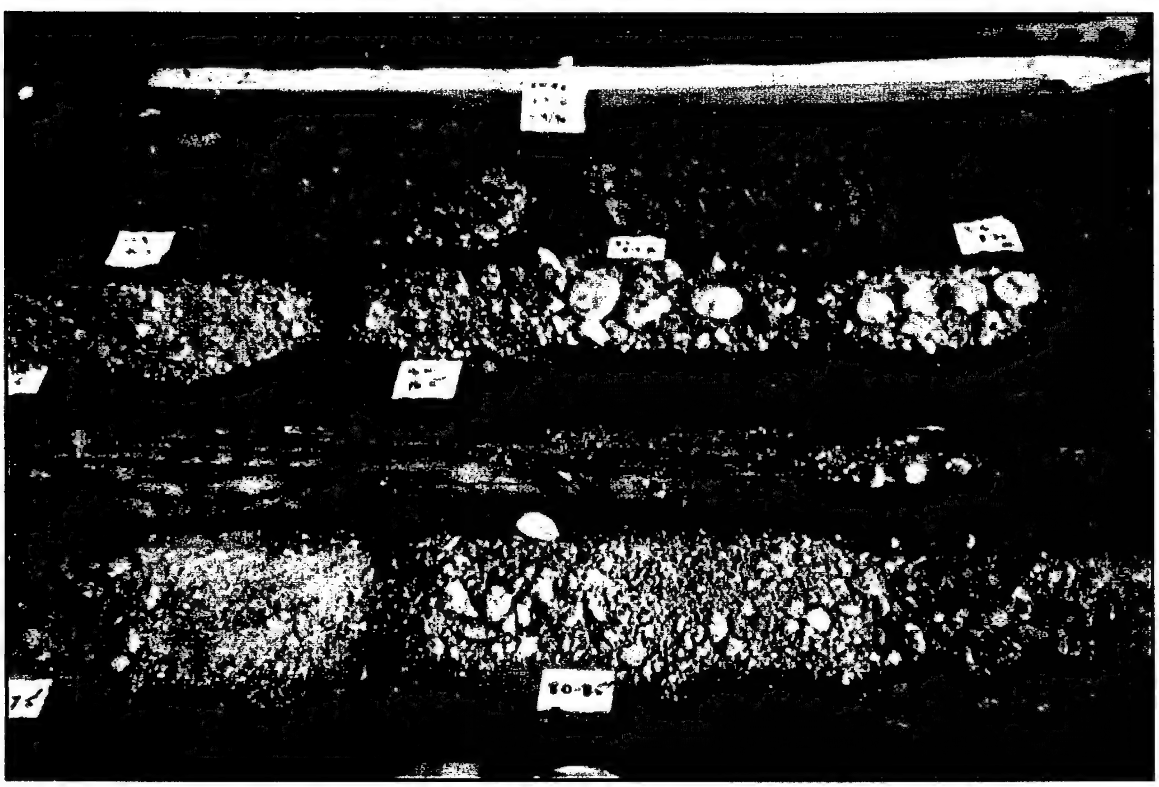
Note: **Temp** = temperature (C); **Cond** = conductivity (mV/cm); **Doc** = dissolved oxygen (mg/L); **DO** = dissolved oxygen (%); **ORP** = oxygen/reduction potential (mV); **SpC** = specific conductivity (mV/cm); **Trb** = turbidity (NTU); **Date** = date of reading in 1998

APPENDIX H

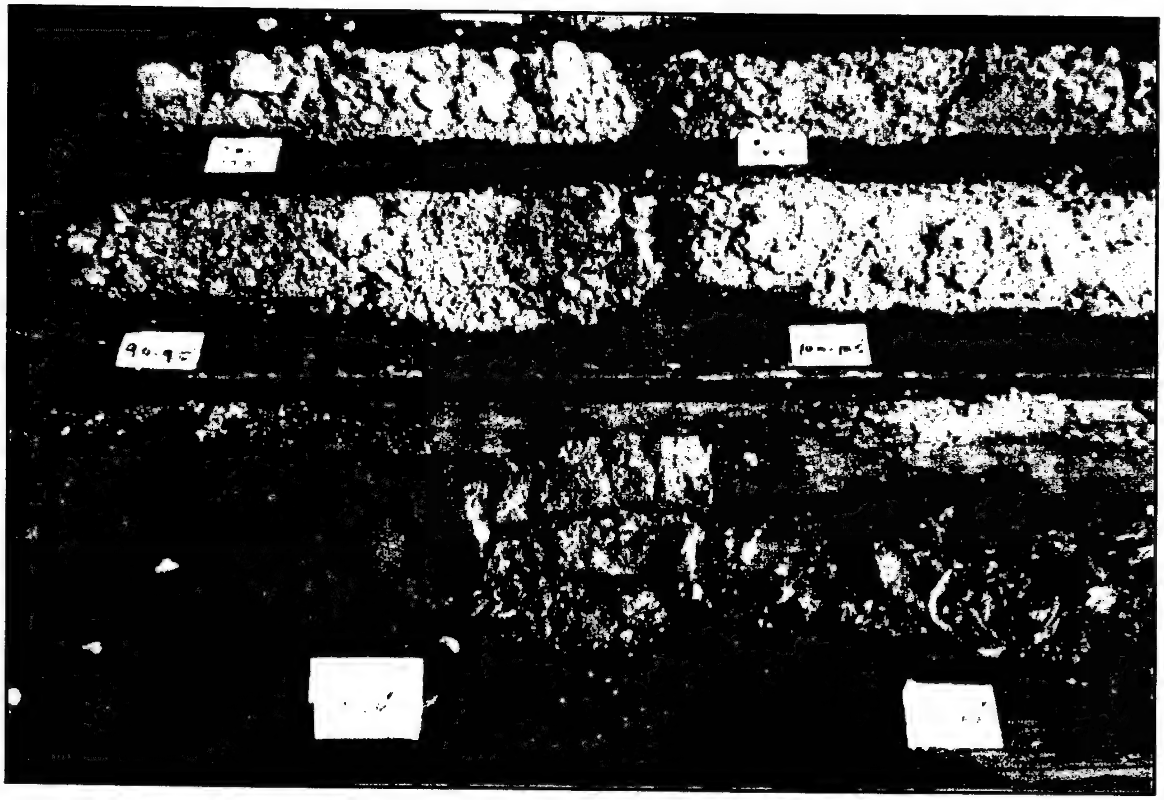
PHOTO OF ON-SITE FIELD AVTIVITIES



Typical Soil Samples (VW-2 Boring) (3/96)



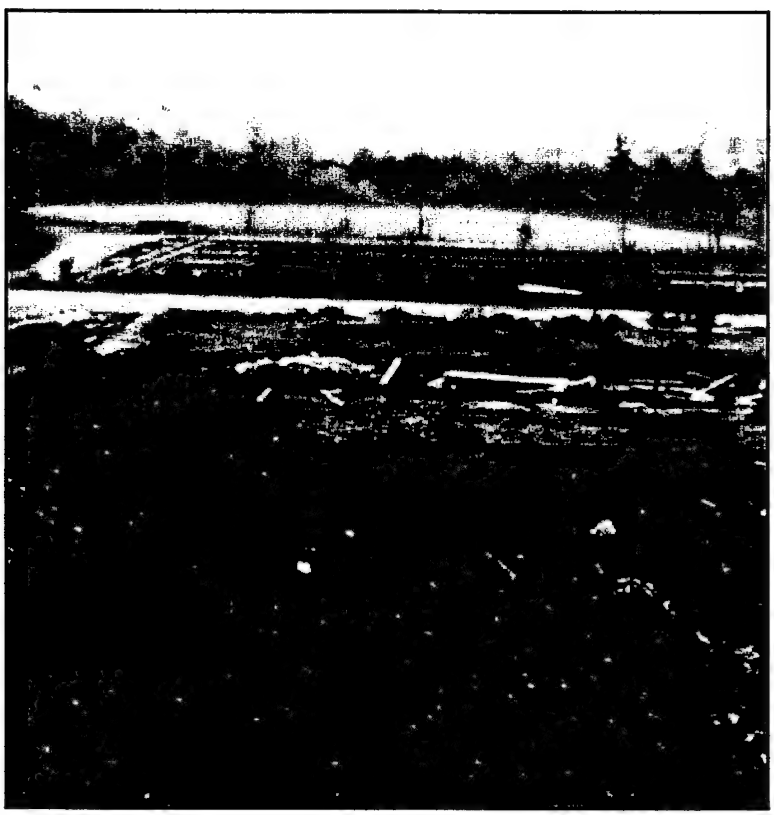
Typical Soil Samples (VW-2 Boring) (3/96)



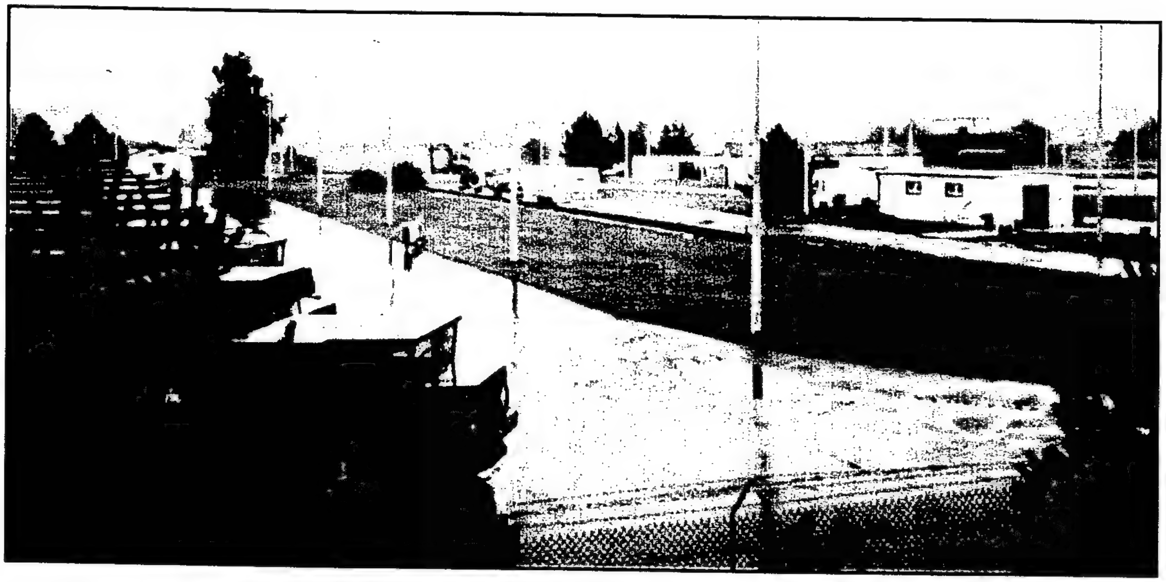
Typical Soil Samples – Very Sandy Soils (3/96)

Typical Aquifer Material – Well-Sorted Sand (3/96)

Drilling a Vent Well at the POL Yard



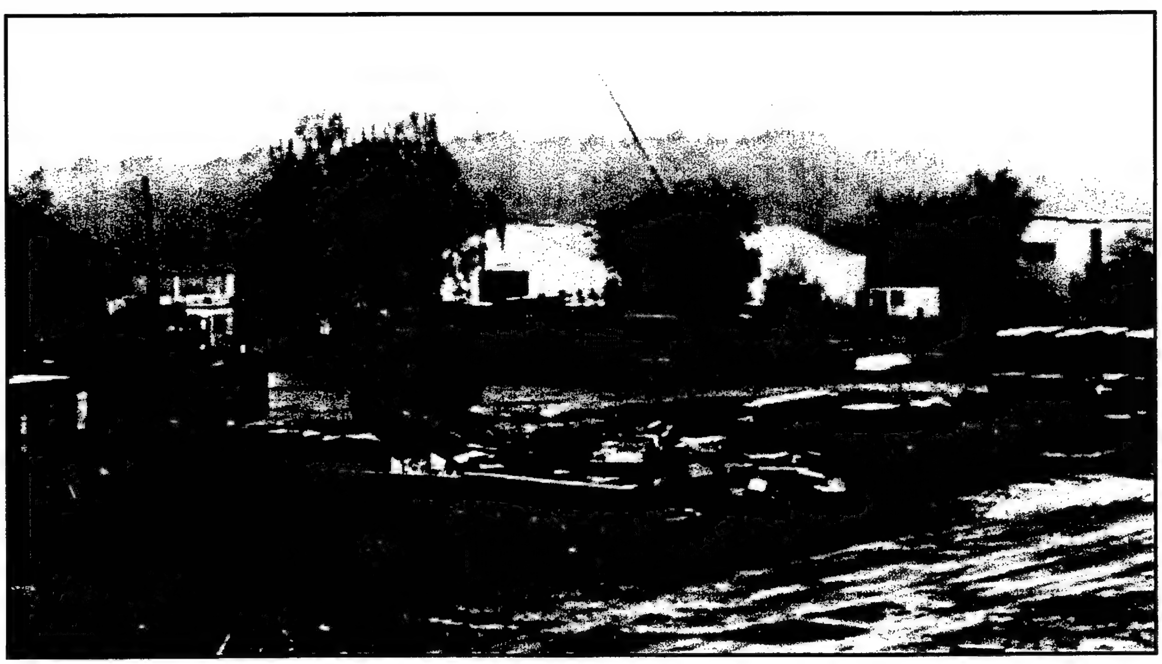
Downgradient View Along Transect from Near GP-1
[In order (foreground to background) former biopile;
oil-water separator; catchment basin (former sand pit); airport] (9/98)



Upgradient View Along Transect from Near GP-1 Location
(View is to southeast into POL yard) (9/98)

View to Northeast from Close to GP-5 Location, Location of Removed Biopile (9/98)

GP-1 Location Looking Into POL Yard (Upgradient) (9/98)

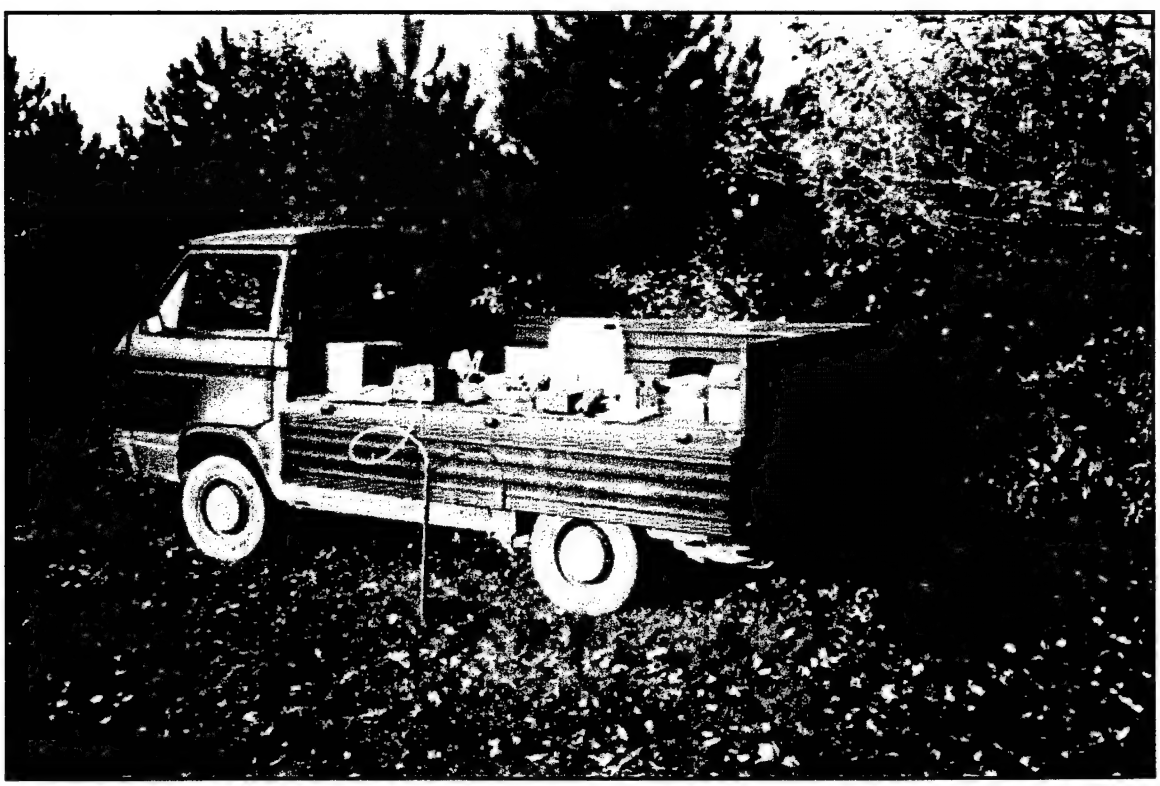


Typical Stockpiled Materials in Area Downgradient of POL Yard (9/98)

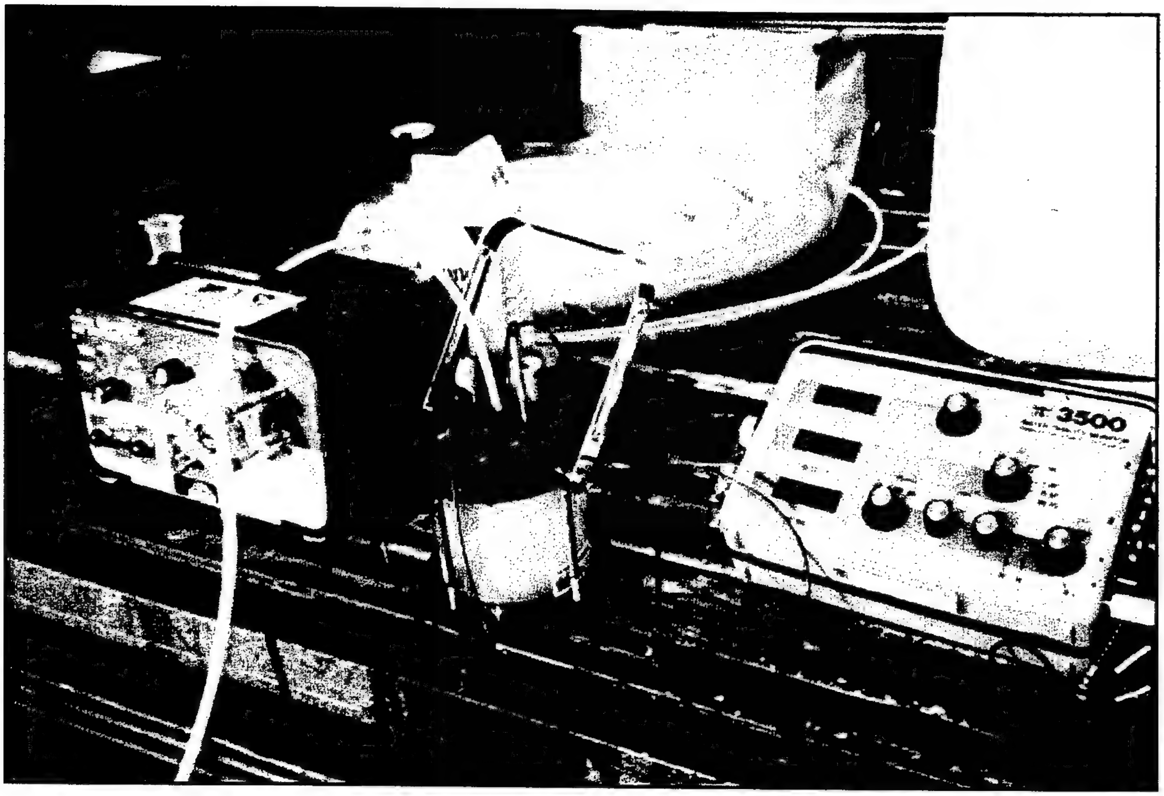
View of Newly-Completed Catchment Basin (9/98)

Geoprobing at GP-10A Location, Note Biopiled Soils Behind Workers

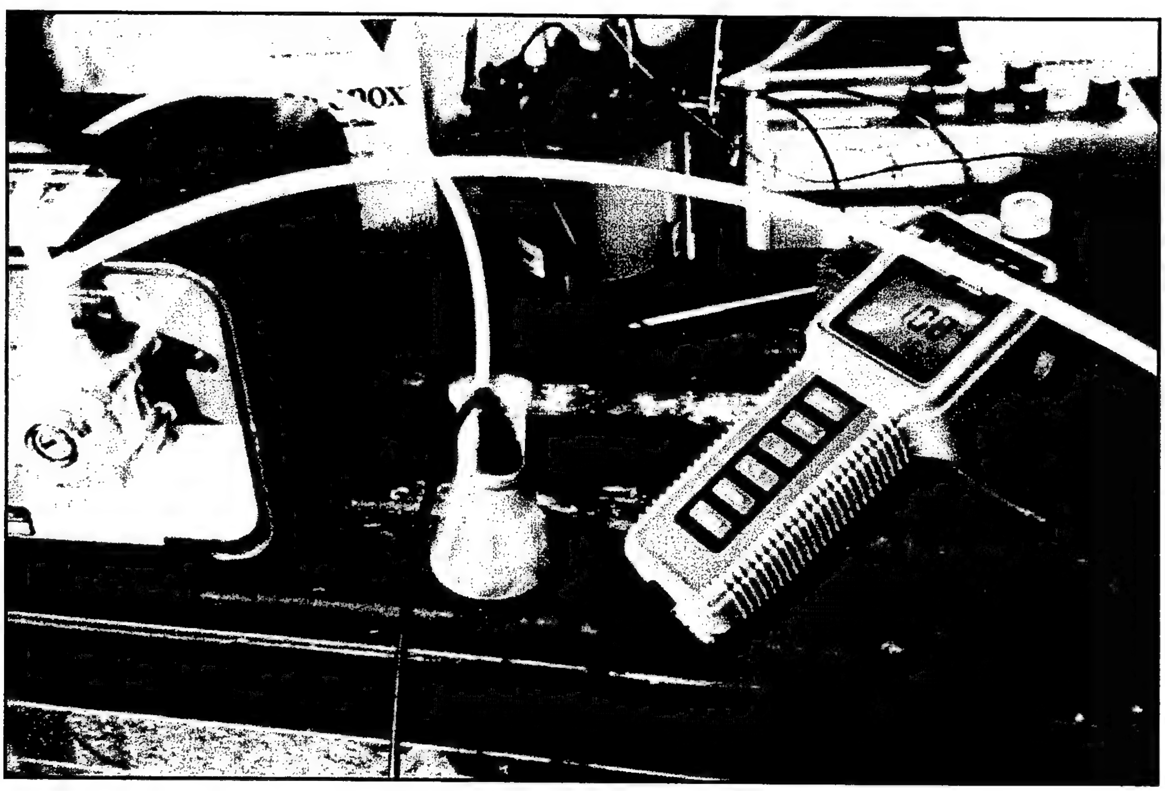
Geoprobing at GP-3 Location (9/98)



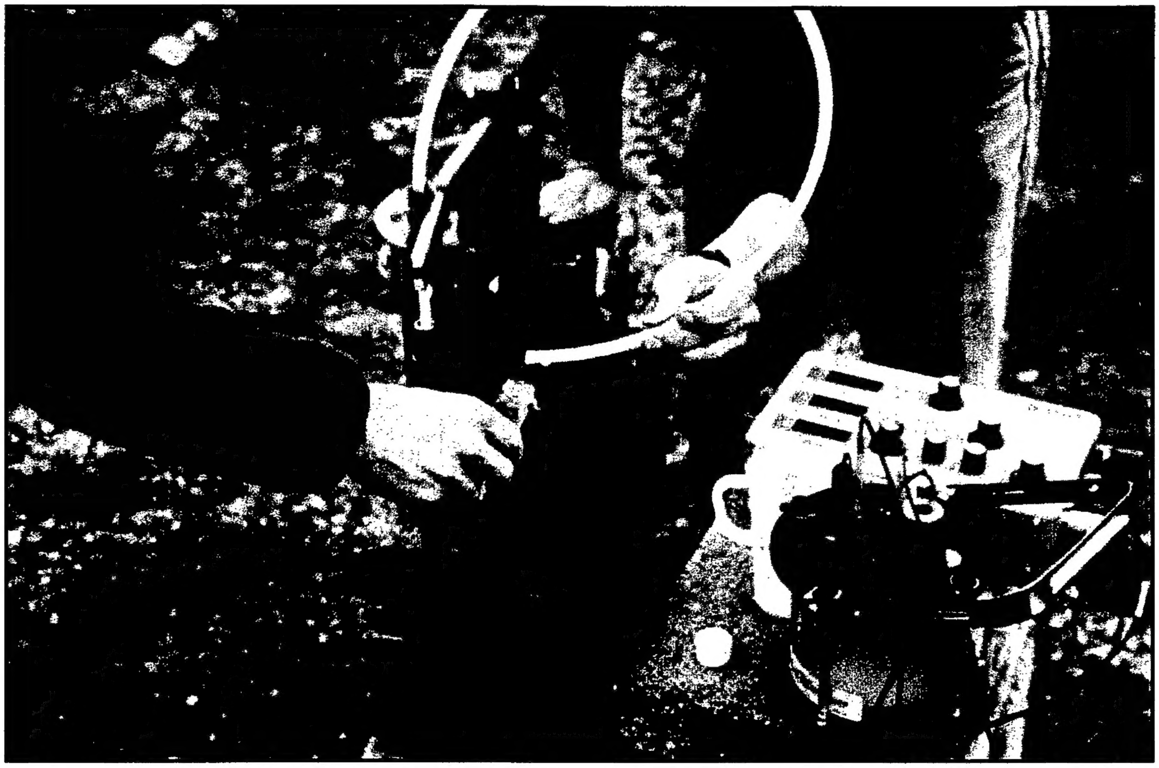
Measuring Probe-Head Parameters at GP-16 Location During Phase 1 (3/96)



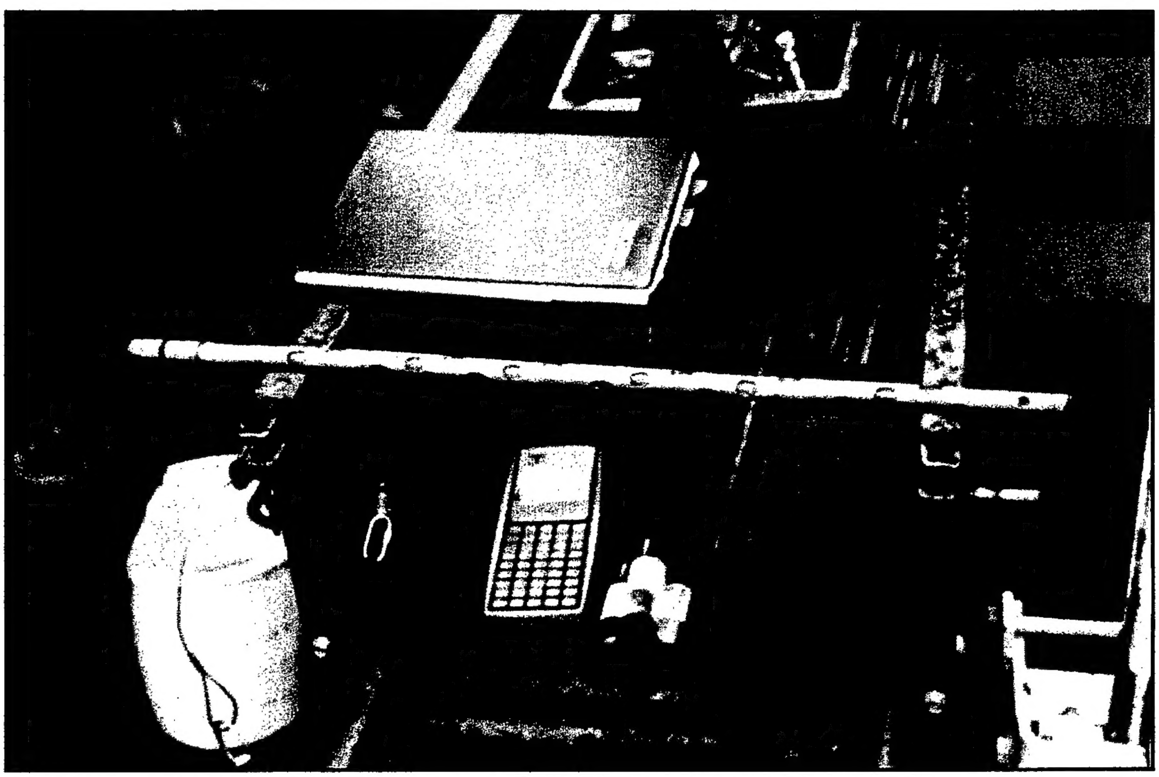
Collecting Probe-Head Measurements During Phase 1 (3/96)



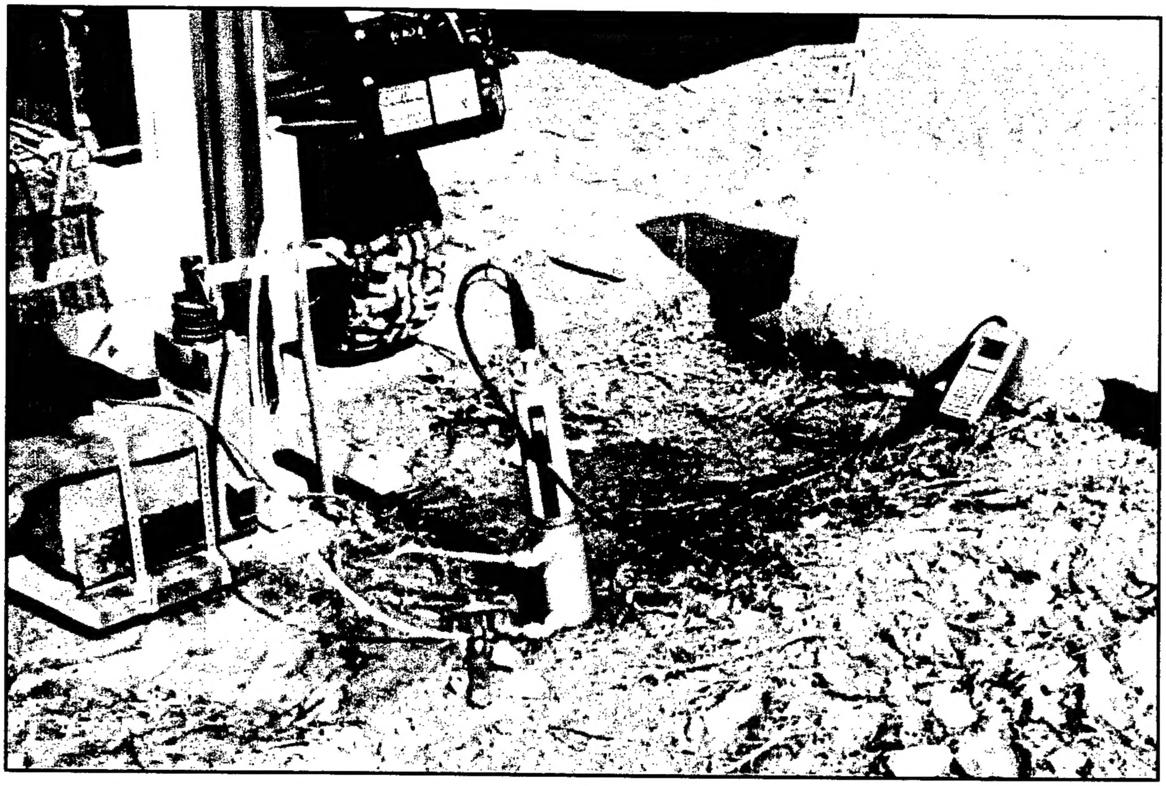
Collecting a Dissolved Oxygen Reading During Phase 1 (3/96)



Collecting a Groundwater Sample with Waterra Pump (3/96)

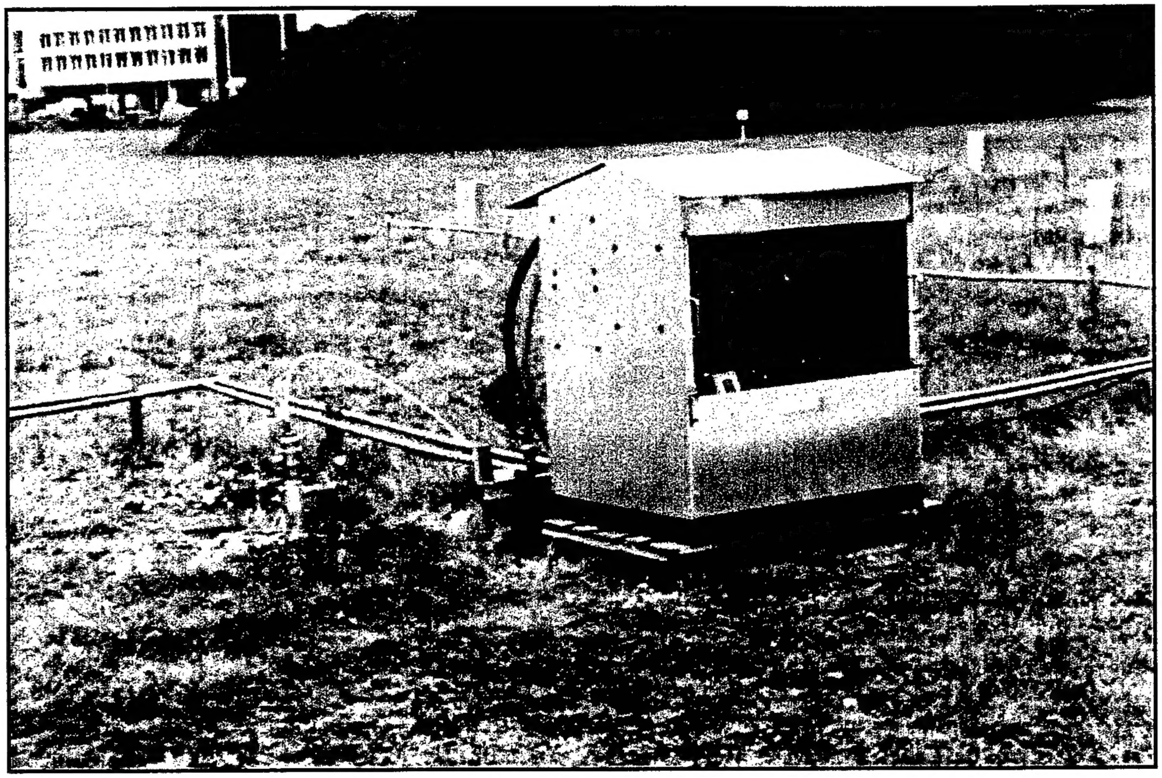


Sampling and Survey Equipment on Back of Geoprobe Unit (9/98)



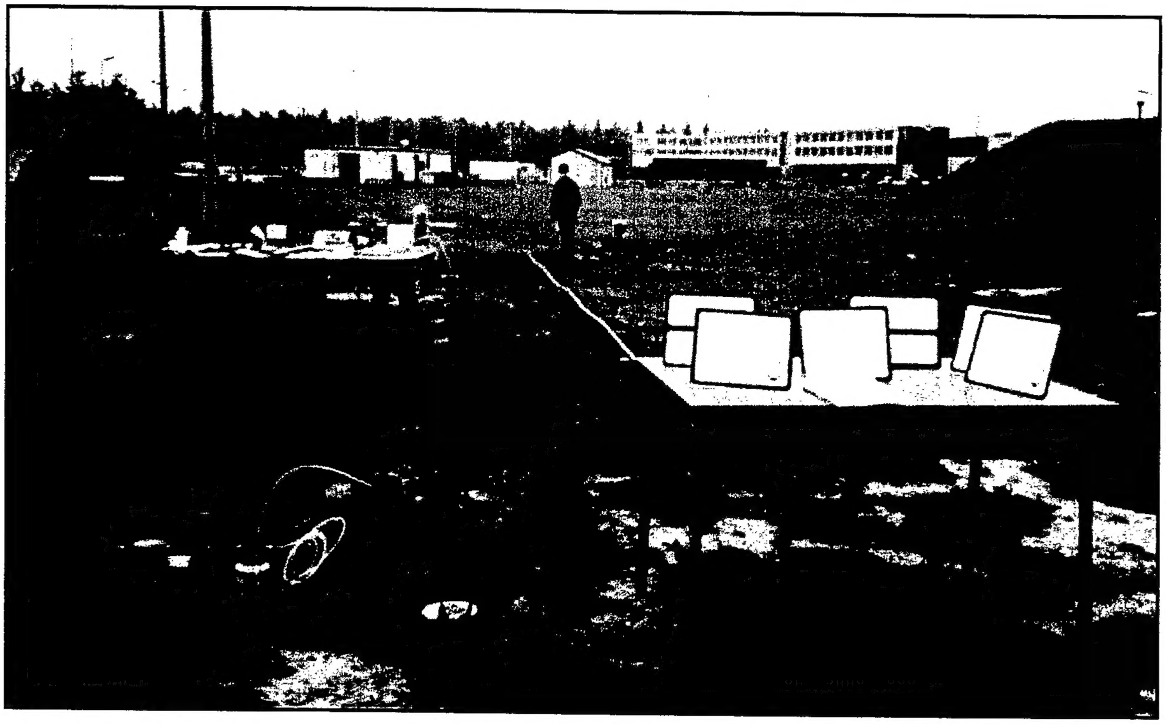
Collecting Probe-Head Measurements at GP-2 During Phase 2 (9/98)

Collecting Measurements at MW-3 Location Within POL Yard (9/98)



POL Yard Bioventing Control Box and Air Pump

Split-Spoon Sampler Display at Joint Technology Conference (10/96)



Bioventing Display at Joint Technology Conference (10/96)

Bioventing Display at Joint Technology Conference (10/96)